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EDITORIAL

IN September 1949, the Board of Management of this Journal wrote to the Faculty of Anæsthetists of the Royal College of Surgeons and offered to present the *British Journal of Anæsthesia* to that body to be its official organ.

This offer the Faculty was prepared to accept, provided that the Association of Anæsthetists of Great Britain and Ireland, who also produced a journal, had no objection. The Association, however, perhaps not unreasonably, did object, and there followed prolonged negotiations between the Faculty and the Association, the purpose of which was an endeavour to attain some working arrangement with which both these parties would feel satisfied. Many schemes were considered, including the production of one single journal, but in the course of time it became clear that it was impossible to achieve mutual agreement, and there seemed to be insuperable legal obstacles to the production of one journal under the auspices of both bodies.

It must be apparent to everyone that unity in the ranks of the specialty is more than ever desirable during the present critical times, and any move which might have prejudiced the extraordinarily close co-operation and spirit of mutual assistance which exist between the various

bodies representing the specialty would have been a grievous error and to be deplored. Consequently, although pages could be devoted to a discussion of the pros-and-cons of the many suggestions which were made during these negotiations, there would now seem to be no point in pursuing the matter further and we are content that our offer, which was made in the greatest good faith, has not been allowed to cause disruption.

Perhaps, however, we might be permitted to make just two observations. In the first place, we appreciate and sympathize with the viewpoints of both these bodies, with whom we would wish to co-operate in every way possible. Secondly and finally, we wish to make it clear that in proposing this transfer of ownership of the Journal to the newly established academic authority—the Faculty of of Anæsthetists—the Board of Management were only pursuing their avowed policy, which is ever to increase the academic standing and prestige of the *British Journal of Anæsthesia.*

It is not the aim of this Journal to enter into the realms of political controversy, but as we owe no allegiance to any party or faction, we may perhaps be allowed to glance at a problem which has caused sore distress to members of our specialty during the past few years. This anxiety and concern was not relieved by the Government's recent circular RHB(50)96, in which was suggested the scope of the Senior Hospital Medical Officer in anæsthesia.

There can be no doubt that all anæsthetists would be united in deploring any situation in which a special grade of "specialists" was perpetuated. In a previous Editorial we have referred to this category as medically qualified

anæsthetic technicians, and a plea that such a class of substandard Consultant is necessary in order to find a niche for those who cannot quite make the grade academically will not be acceptable to any responsible person. As with any other branch of medicine, those who cannot quite make the grade should turn to some other sphere to which they would be more suited. That surgeons might wish to make use of the technical skill of such individuals cannot, in any circumstance, justify the creation of this category.

On the other hand, there will be many who might think it reasonable that the normal ladder from House Officer to Consultant should include the various grades of Registrarship and the final rung should be that of Assistant Consultant. The attainment of the position of Assistant Consultant Anæsthetist would then be an accepted step towards maturity, and the ranks of the full Consultants would be replenished in the normal course of events from such individuals.

It might be envisaged that a Hospital or a Hospital Group should have on its establishment so many Consultants and so many Assistant Consultants. This would be no new conception and would seem rational and entirely acceptable. However, those in whose hands the future of the profession lies would no doubt also take care that the remuneration offered to such Assistant Consultants was more realistic than the scale which at present applies to the Senior Hospital Medical Officer. This scale should enable a man to maintain a standard of living in keeping with his position and responsibility. Such provisions would indeed cast a new light on the Ministry of Health's proposals and would remove any suspicion of an attempt to "down-grade" this and other specialties.

THE USE OF d-TUBOCURARINE CHLORIDE FOR CÆSAREAN SECTION—A REPORT OF 210 CASES

By H. T. DAVENPORT

THE object of this paper is to examine the results of a certain form of anæsthesia used for 210 consecutive Cæsarean operations during one year. A statistical review has been published elsewhere of a larger series to indicate the broad outcome of this and some other methods (Davenport and Prime, 1950).

The use of one anæsthetic technique by one anæsthetist in the same hospital over a short period has reduced the variables in such a survey.

TECHNIQUE

Premedication consisted of 0.6 mg. atropine given intramuscularly 30 minutes before the operation, or intravenously in case of emergency.

The patient was placed upon the operating table and the abdomen prepared by the surgeon who then stood "knife in hand". To facilitate venipuncture both arms were extended on supports attached to the table. A test dose of 5 mg. d-tubocurarine chloride (Tubarine) was given and the patient observed for a short period for undue reactions, after which an estimated addition of d-tubocurarine chloride was given. Immediately following this, sleep was induced with 10 per cent thialpentone

(Kemithal) and maintained with cyclopropane given by a closed carbon dioxide absorption system with which respiration could be aided manually if necessary (Gray, 1947).

The incision was made as soon as the eyelash reflex was abolished and 0.5 or 1 mg. ergometrine was given intravenously as the head of the child was about to be delivered. A post-operative analgesic, morphine or Omnopon, was given before the patient returned to the ward, together with the antidote (neostigmine) for any depressed upper intercostal muscle activity.

The average dose of d-tubocurarine chloride required was 15 mg., ranging from 8 mg. to 20 mg., and of thialpentone an average of 0.4 g. was needed to induce sleep, the range being 0.3 g. to 0.7 g. On eight occasions a second dose of thialpentone was employed after delivery to gain more depth as and when needed.

During the latter stages of some operations trichlorethylene was administered by the semi-closed method, with the object of retaining some analgesia for a period until the post-operative sedation took effect. This was found effective owing to the slow elimination of this agent.

THE MATERIAL

There had been no selection of cases and the indications for operation given by the obstetrician were as follows. It is apparent that in the majority of cases there was a combination of factors.

(Throughout this paper infant deaths are shown by asterisks (*) at the appropriate places.)

Disproportion	91
Repeat operations	77*
Bad obstetrical history, including relative sterility	37*
Fœtal distress	33*
Toxæmia	29
(Mild, 14; severe, 10; pre-eclamptic, 5)	
Elderly primipara	25
Contracted pelvis	25
Dystocia (inertia or excess retraction)	19
Breech presentation	17
Maternal distress or infection	13
Placenta prævia	13**
Malposition	12
Heart disease	11
Prolapsed cord	4
Fibroid uterus	4
Diabetes mellitus	3
Previous colpoperineorraphy	3
Miscellaneous	13
(Poliomyelitis, 2; severe spine deformity, 2; pulmonary T.B., 2; T.B. of the knee, 1; T.B. of the hip, 1; ovarian cyst, 1; detached retina, 1; disseminated sclerosis, 1; ankylosed hip, 1; cloaca with colostomy, 1)	

Eighty (38 per cent) of these cases were emergency sections and their preparation was limited. This indicates the probability of a full stomach and nervous distress or tension in these patients.

The mothers were also divided into two classes, (*a*) those having general disorders which would be considered detrimental to performing an operation, and (*b*) those who would be considered fit for any such procedure (Heard, 1946).

	Emergency labouring	*Elective*	*Total*
(*a*) Abnormal	37*	48*	85 (40.5 per cent)
(*b*) Normal	43*	82**	125 (59.5 per cent)
Total	80	130	210

A transverse lower segment operation was performed through a midline sub-umbilical incision in the majority

of cases. The exceptions were 7 transverse Pffansteil's approaches, 2 classical operations and 1 Porro hysterectomy. In four instances a ventral hernia was repaired and in twenty-three sterilization was performed at the time of the operation.

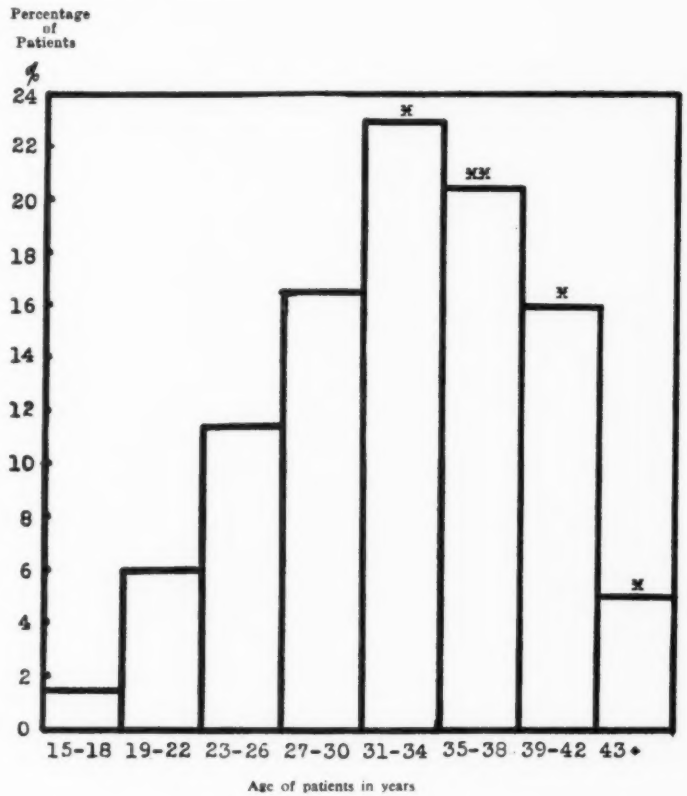

FIG. 1

The distribution of patients according to age. Number of patients 210

When the operation began there was evidence of a living fœtus in all except one case. In every operation a living child was delivered which was viable by maturity standards, i.e. apparently beyond the 28th week of development.

The average age of the patients was 32 years, with a range of 16–45 years (fig. 1).

ANALYSIS OF MATERNAL RESULTS

(*a*) *Operative incidents*

The average duration of this operation was 39 minutes, with a minimum of 20 minutes and a maximum of 135 minutes (fig. 2).

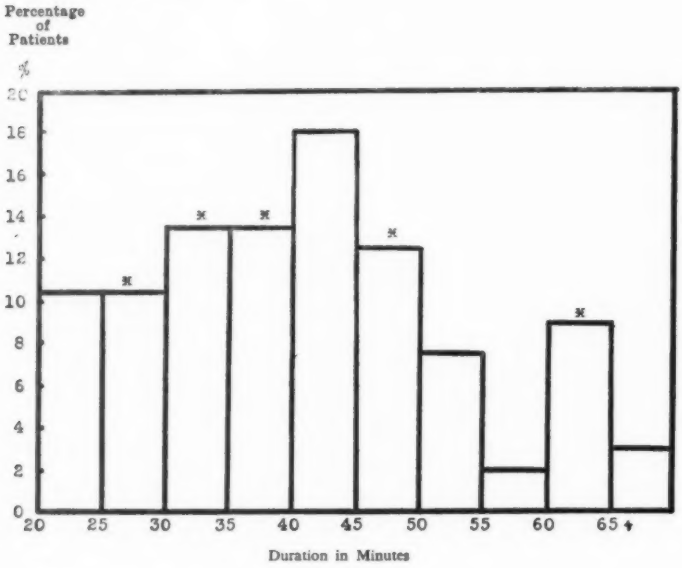

FIG. 2
Length of time taken for operation

The average time for delivery of the fœtal head was $7\frac{1}{2}$ minutes, with a range of 2–17 minutes (fig. 3).

The technique was not thought to necessitate undue hurry and in many repeat operations old scar tissue was excised at the beginning of the operation. On no occasion was it necessary to change the technique owing to inability

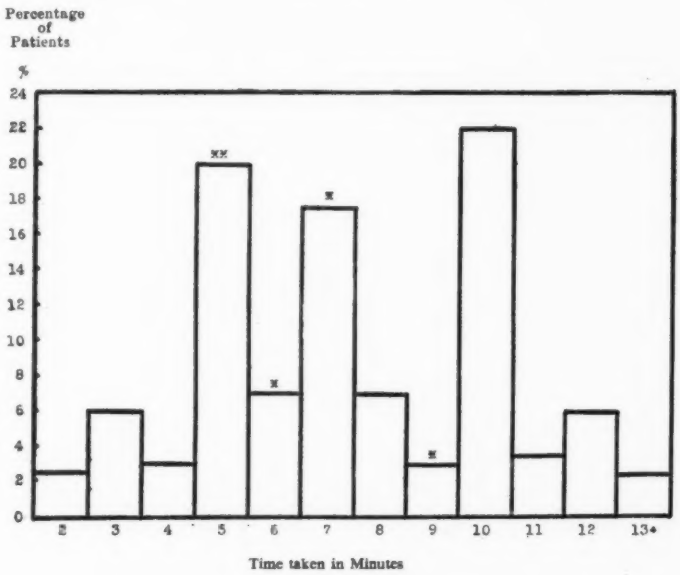

FIG. 3
Length of time from induction of anæsthesia to delivery of the fœtal head

to perform a venipuncture, but once it was necessary to finish the induction by the inhalation method owing to the dislodgement of the needle.

Two patients became distressed after the initial dose of d-tubocurarine chloride, which had acted rapidly and

markedly, but immediate intravenous induction of sleep abolished any memory of this discomfort.

A natural airway was maintained whenever possible as it was recognized that the introduction of a pharyngeal airway would increase the likelihood of vomiting and laryngospasm. It was found that when conditions necessitated aided respiration, gas could sometimes pass into the stomach. This amounted to considerable quantities on two occasions, one patient needed a stomach tube inserting, but neither showed adverse effect later.

On fourteen (6.5 per cent) occasions endotracheal tubes were inserted, of which seven may be termed prophylactic, as indicated by the following reasons:

Case 1. Short thick neck—no atropine.

Case 2. Severe heart disease.

Case 3. Excessive secretion necessitating bronchial aspiration.

Case 4. Short thick neck.

Case 5. Short thick neck.

Case 6. Marked muscular flaccidity liable to lead to airway obstruction.

Case 7. Intended hysterectomy.

The remainder may be considered accidents requiring this artificial airway as treatment.

Case 8. Laryngospasm—? minor regurgitation stimuli.

Case 9. Laryngospasm—pharyngeal airway stimuli.

Case 10. Cyanosis with difficulty in inflation—? bronchospasm.

Case 11. Cyanosis with difficulty in inflation—? bronchospasm.

Case 12. Stridor with some cyanosis in a patient with heart disease.

Case 13. Immediate gastric regurgitation.

Case 14. Immediate gastric regurgitation.

It was found that curarization made it easy to correct such incidents provided the necessary apparatus, e.g. suction, was always available.

The pulse pressure and rate were found in many patients to return to normal upon induction, although they were, in a large proportion of the unsedated subjects, greatly elevated pre-operatively.

Severe hypotension occurred rarely and each time there was relevant hæmorrhage or hypoxia. None of the agents the anæsthetist used was associated with the drop in blood pressure.

Uterine blood loss generally was not great as retraction was good—any large low cervical vein needing control was easily accessible immediately after delivery.

Relaxation was always to the surgeon's satisfaction and the bowel did not intrude upon the wound, although peritoneal packing was not a practice of any of the surgeons.

Cardiac arrhythmia was rare, possibly because no more than 25 per cent by volume of cyclopropane was needed as plane 1 was always considered adequate depth of anæsthesia. On the four occasions in which extrasystoles or tachycardia was detected ether was substituted for the cyclopropane with the desired result.

As seen from the intubation records, during the course of the anæsthetic laryngospasm occurred on three

occasions, and what was considered as possible bronchospasm occurred twice.

Four patients vomited copiously after operation, but all had active pharyngeal and laryngeal reflexes and they did not apparently aspirate any stomach contents.

Intravenous neostigmine, together with atropine (usually a combination of 5 mg. and 1.2 mg. respectively) was given to counteract the residual upper intercostal inactivity in 51 (24.5 per cent) patients in whom the operation had been completed within 25 minutes. No ill-effects were observed from this measure and deeper respiratory excursions always followed the injection.

(b) *Post-operative sequelæ*

The relation between the pre-operative and post-operative states is of great importance, but with emergency obstetric cases it is often impracticable to obtain a careful pre-operative assessment. Such difficulty prevailed in nearly 50 per cent of the cases reviewed here. Post-operative conditions are, therefore, merely enumerated.

The respiratory system was affected in 26 (12.5 per cent) patients. Thirteen had cough as the only evidence of disease, 7 produced sputum and their condition was diagnosed as bronchitis, 5 gave definite clinical signs of atelectasis and there was a single case of dyspnœa with cyanosis of one day duration, the cause of which was not diagnosed.

Discomfort due to abdominal distension was complained of by seven patients; all were cured by simple remedies.

Urinary disorders, all of which improved from the time of delivery, were in most instances attributable to the obstetric condition. Immediate post-operative retention necessitated catheterization on four occasions.

Wound infection, generally with hæmatoma formation, was found in nine instances, one leading to some disruption of the incision line, necessitating resuture.

Thrombosis of venous channels was found in eight patients, twice of considerable severity in the leg and once in the arm region when ergometrine had been injected into the subcutaneous tissue. Two patients developed signs of ketosis and one of hypoglycæmia.

Miscellaneous conditions were found in single cases but were not related to the anæsthetic except possibly one of considerable vaginal bleeding within 24 hours of operation.

From the temperature charts it was found that 54 patients had some pyrexia, the rest being completely afebrile, and it is of interest that 44 women were given antibiotic drugs for some reason.

Analysis of Infant Results

There were 104 female and 108 male infants delivered, including two sets of twins, making a total of 212 infants.

The distribution of their weights was as in figure 4.

Thirteen of the infants delivered were immature, taking as a criterion of immaturity a birth weight of less than $5\frac{1}{2}$ lb. (2.4 kg.).

The infants on delivery were taken by a nurse to the sterile cot where she undertook toilet of the pharynx by suction with a soft catheter. If the infant did not cry within 1 to 3 minutes a doctor undertook further treatment, such as repeated suction and oxygen administration through a Gibbert-Blakeley bag, with which intermittent pressure no greater than 20 cm. of water was applied. Alphalobeline was occasionally given into the cord veins.

More vigorous resuscitating measures were used when the infant reached the flaccid stage with pallor and

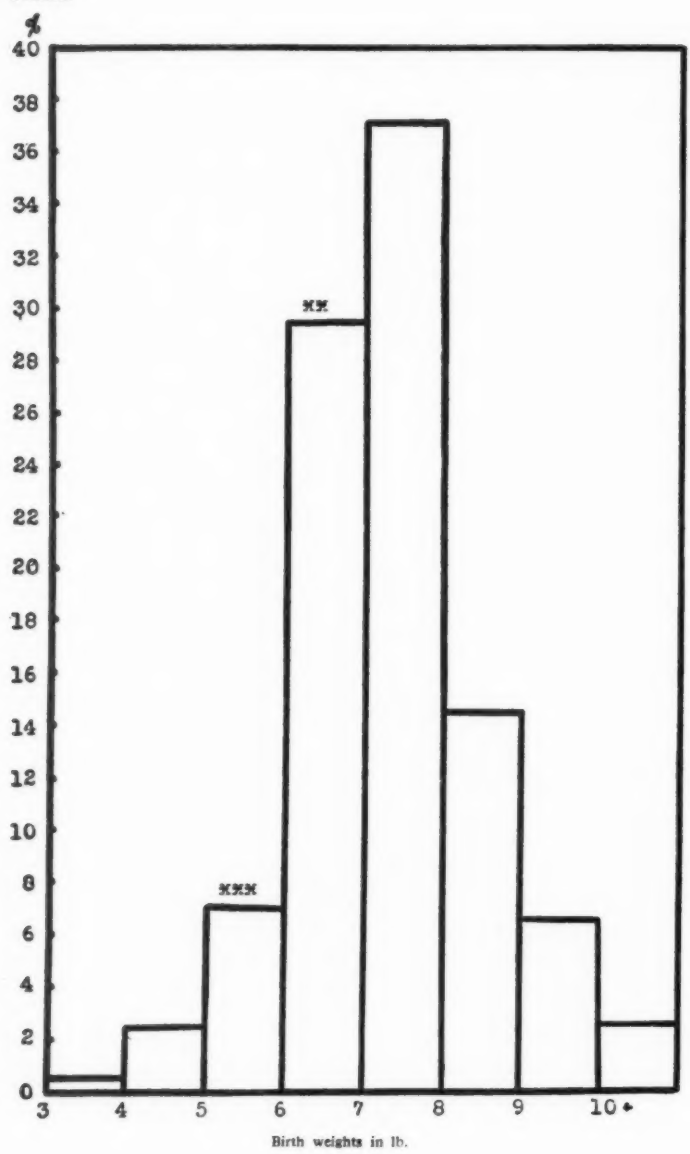

FIG. 4
Distribution in the infants' weights

decreased heart rate. They consisted of pharyngeal and tracheal toilet with direct vision, using a Shadwell laryngoscope, endotracheal intubation with size 00 Magill tube and further intermittent oxygen insufflation by direct connection to that tube. Oxygen tents on return to the ward were also used whenever it was deemed necessary. The number of times on which these measures were employed is tabulated below.

	Emergency (labouring)	*Elective*	*Total*
Spontaneous respiration	49*	89*	138 (65 per cent)
Some resuscitation	26	35	61 (29 per cent)
Intubation	7*	6*	13 (6 per cent)
Total	82	130	212

Three male and two female infants (2.5 per cent) did not survive the neonatal period.

In attempting to find some cause for the infant deaths certain factors have to be taken into consideration; first, the health of the mother, which clearly must be of importance in this connection; secondly, the viability, degree of maturity, the presence of congenital difficulty or disease of the fœtus, as well as its presentation and position, are important, and thirdly, complications of labour and delivery must be considered. No direct correlation has been found between these factors and infant deaths in this series. Age and parity of the mother may, however, have been a factor as all those whose babies died were multiparæ and over 33 years of age. A critical view may indict certain points in the maternal history or infant's progress when a reason for death is being sought in an individual case.

Elective

No.	*Age*	*Parity*	*Pre-operative facts*	*Infant facts*
1	43	5	Recent vaginal repair. Pale, undernourished.	Baby cried statim. Weak with sternal retraction. *O_2 tent ordered late.*
2	36	2	Considerable A.P.H. two weeks before. Placenta prævia.	Placenta incised for delivery. Baby strong—cried well. *O_2 tent used late.*
3	35	2	Repeat operation.	Baby only gasped—cyanosed. *Delayed intubation owing to defective apparatus.*

Emergency

No.	*Age*	*Parity*	*Pre-operative facts*	*Infant facts*
4	33	3	2 *previous stillbirths.* Elective operation refused. 58 *hrs. ineffective labour.* No F.H.H. for 2 days—then mother felt movements.	Baby flaccid, much meconium in trachea. Intubated, only gasped, lungs well expanded at P.M.
5	39	2	Considerable active A.P.H. Placenta prævia.	Baby cried well. Pale with *R.B.C.'s* 4,060,000. *Not transfused.*

An autopsy was performed on each of the five infants, the results being:

No.	*Age*	*Weight*	*P.M. diagnosis of cause of death*
1	10 hrs.	6 lb. 1 oz.	Bilateral lower lobe atelectasis.
2	72 hrs.	6 lb. 3 oz.	Atelactasis.
3	3 hrs.	4 lb. 11 oz.	Patchy atelectasis.
4	3 hrs.	5 lb. 13 oz.	Intraventricular hæmorrhage.
5	24 hrs.	5 lb. 3 oz.	Cerebral asphyxia with atelectasis.

Apart from the special care necessary for the premature and Rh infants, all but the following progressed as if delivered normally with good feeding habits and increased weight at the end of the observed time.

Eight gave indications of chest disease.

Four had signs of cerebral anoxia.

Four had minor intestinal disorders which were easily cured.

Two had œdema and one jaundice, the cause of which was not determined.

Three had conjunctival infection.

Three had some signs of mongolism.

COMMENTS

In an attempt to examine this anæsthetic technique impartially the complete hospitalization of the mothers and infants was followed. The records produced may enable readers to compare this innovation with other methods similarly reviewed. Also the dangers will be apparent to those intending to try this method.

The curare sequence described was found pleasant and convenient for patients and surgeons and they often expressed a preference for it over other methods previously experienced—the wisdom of their choice needs to be proved. One patient had had difficulty in breathing and a choking feeling owing to full curarization with delay in the induction of sleep at her previous operation. She then developed an extreme terror that her next pregnancy should necessitate a repetition of this feature. This should be avoided in future.

To employ this complex sequence of drugs a specialist anæsthetist has been necessary and this seems to be the ideal aim for all operative deliveries. Perfect team work and preparation to deal with all complications was essential at all times. For this an extra doctor with knowledge of resuscitation should be present, preferably a pædiatrician or an anæsthetist, who then supervises the infant's care

for the next 24 hours, it being well recognized that the incidence of neonatal morbidity and mortality is greatest during this period.

Delay in institution of a resuscitation routine and subsequent care, e.g. respiratory tract toilet and oxygen therapy, may be disastrous. The decision of when to intervene and whether intensive efforts are justified by the state of the salvaged infant need further investigation.

SUMMARY

At Liverpool Maternity Hospital 210 patients underwent Cæsarean section with curare as an adjuvant in their anæsthesia during 1949. The outcome has been studied.

There were no maternal deaths but five infants did not survive the neonatal period.

Some impressions are discussed which stress the advantage of closer co-operation of anæsthetist, obstetrician and pædiatrician.

The author is indebted to the Staff of Liverpool Maternity Hospital for their co-operation and permission to publish this report.

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THE FLOW OF GASES IN A SEMI-CLOSED ANÆSTHETIC SYSTEM

By L. MOLYNEUX *and* E. A. PASK

THE direction of the flow of gases in a semi-closed system is clear enough, but the amount of gas which at exhalation goes either back towards the reservoir bag or out through the expiratory valve is not so easy to assess. It is possible to write a formula which should predict these quantities, if certain reasonable assumptions are made about the form of respiration and the promptness of action of the expiratory valve.

For example, let us assume that the respiration approximates to square form in respect of rate of flow into the lungs during the actual act of inspiration and out from the lungs during expiration; let us also assume that the duration of inspiration equals that of expiration. (See fig. 1.) Notice that the height of the line BC above the

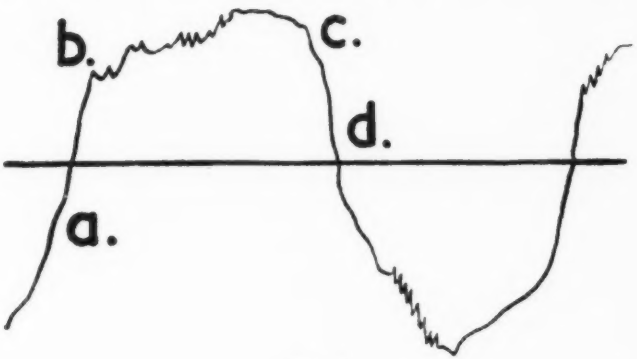

FIG. 1

Rate of flow of gases into and out from the lungs during respiration

base line represents the *rate* (e.g. in litres per minute) at which the gases flow into the lungs. The *tidal volume* is represented by the area enclosed with ABCD.

Now let VX = the volume of gas flowing back towards the bag at expiration; VT = tidal volume; VF = rate of flow of gases from the flow meters into the system; N = number of respirations per minute. Then it can be shown*:

$$VX = \left(VT - \frac{aVF}{2N} \right) \frac{2NVT}{aVF + 2NVT}$$

The quantity a is the "duty cycle" of the respiration. In other words, a = period of inspiratory and expiratory activity divided by interval between onset of succeeding inspirations. In the case discussed, $a = 1$ and may be ignored. This is the case in "to and fro" respiration in anæsthesia, but during induction a may have a value less than 1.

Now it is possible to discover whether these relations really do hold true with reasonable reliability in practical anæsthetic circuits, if a very rapidly responding flow meter can be introduced into the system at the point "Z" in figure 2. Such a flow meter has been constructed. It consists of a very porous glass disc which offers a slight resistance to the flow of gas. This resistance is about 2 cm. of water at 100 litres per minute—about the same as that of a Water's canister. The slight resistance is sufficient, however, to generate a small differential pressure proportional to the instantaneous rate of flow of the gas. This pressure deflects a sensitive aneroid whose movements can be recorded by electrical means and finally, in terms of rate of flow, appear as a pen trace upon moving paper. Figure 3

* See appendix.

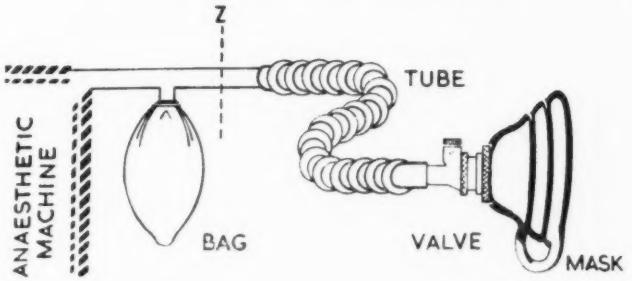

FIG. 2
Schematic diagram of anæsthetic circuit to show position of flow meter

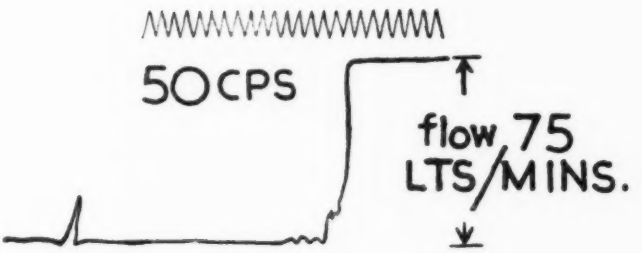

FIG. 3
Response of the flow meter when the flow through it is changed instantaneously

shows a trace obtained with the flow meter when the flow through it was changed artificially as nearly instantaneously as possible. There is little " overswing " and the " rise-time " in registering the change (allowing for the curvature of the pen-trace) is less than 1/40 second.

When the flow meter is placed in the system at the point " Z " (fig. 2) a tracing is produced at each respiration of which figure 4 is an example. ABCD indicates the rate of inflow to the lungs during inspiration and the area enclosed, ABCDA, measures the tidal volume. DEFG

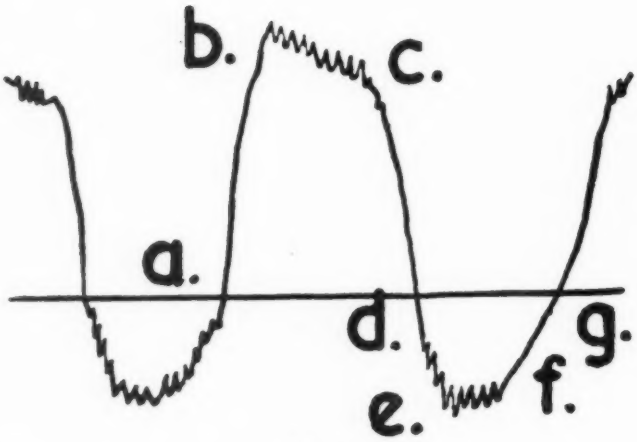

FIG. 4
Rate of flow of gases in an anæsthetic circuit during respiration

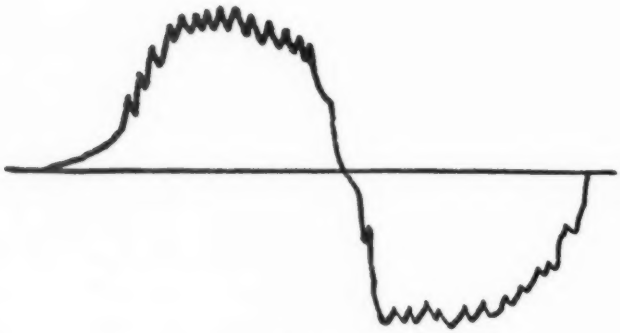

FIG. 5
Rate of flow of gases into and out from a respiration pump used to simulate respiration

shows the rate of back flow towards the reservoir bag and the area DEFGD measures the amount of gas which flows back. The difference between the area ABCDA and DEFG is accounted for by the gas which flows out through the expiratory valve.

The problem is essentially physical rather than physiological, so initial measurements were made with a respiration pump in place of the patient's lungs. The form of the respiration is shown, as measured by the flow meter, in figure 5, and it will be seen that it fairly closely resembles that of normal respiration.

Figure 6 is a graph indicating the relation between the rate of delivery of gas from the flow meters and the " back flow " during expiration. The curves are plotted for various " tidal volumes " and the respiratory rate was always 25 per minute. The calculated curves using the formula are shown as dotted lines and it will be seen that there is fair agreement. Figure 7 shows similar curves using a slightly different form of pump respiration with a " duty cycle " of 0.8. Again, the calculated curves are dotted and again agreement with the experimental results is quite good.

Figure 8 shows similar curves from anæsthetized patients. In each case, a mask was used. It is not easy in clinical cases, using a semi-open circuit, to state tidal volumes precisely, since this quantity varies from respiration to respiration. In order to plot the calculated curve which corresponds to any particular experimental one, it is necessary to know the tidal volume, since the curves are different for each tidal volume. Since it is impossible in practice to determine the tidal volume precisely, in each case we selected a calculated curve, for comparison with the experimental one, which corresponds with the experimental curve at the 10 litre per minute point.

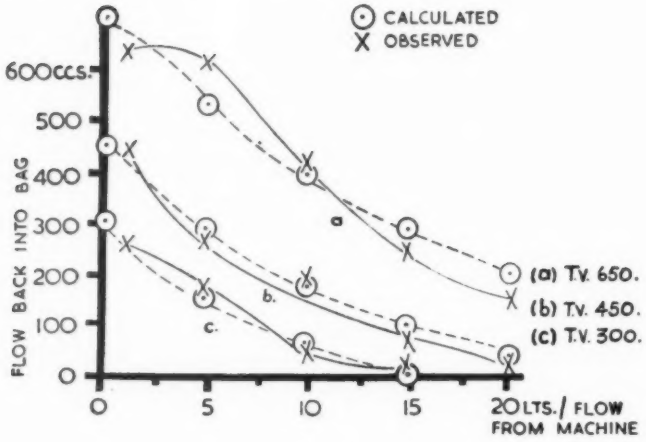

FIG. 6

The relation between the rate of delivery of new gases from the flow meter and the back flow into the reservoir bag during expiration. The curves are plotted for differing tidal volumes

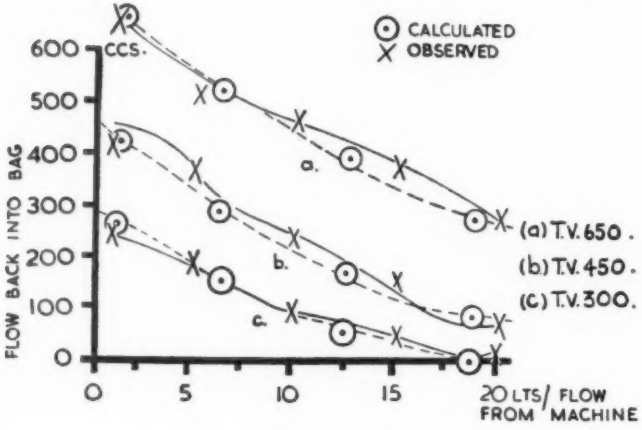

FIG. 7

As Fig. 6 but using a different form of simulated respiration

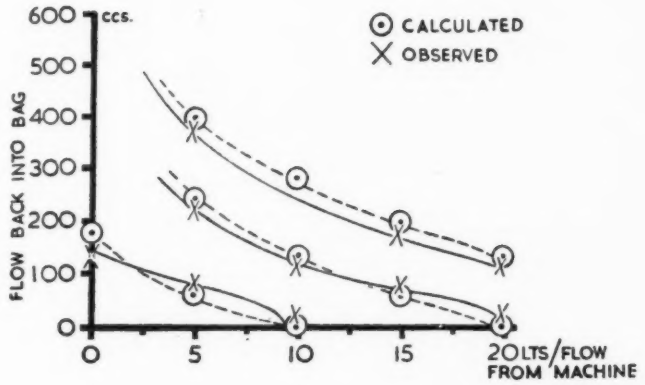

FIG. 8
As Fig. 6 but where measurements were made upon anæsthetized patients

It will have been noticed that no mention has so far been made of the tension of the expiratory valve or the volume of the reservoir bag. Reflection shows that neither factor can be expected to be of first importance. In the case of the bag, only the amount of gas which is taken from it at inspiration can find room to enter it at exhalation, less the amount which has meantime flowed in from the meters. In the case of the expiratory valve, as much gas must leave the system in a minute as enters it, and, leaks excepted, the expiratory valve is the only major exit portal. If the valve be tight, the pressure within the system must rise in order to ensure this. It is not suggested that the bag size and valve tension have no importance in a practical system wherein there are leaks, but they are not primary. Figure 9 shows the effect upon " back flow " of tightening the expiratory valve and it can be seen that the influence is not great. The " resistance " of the expiratory

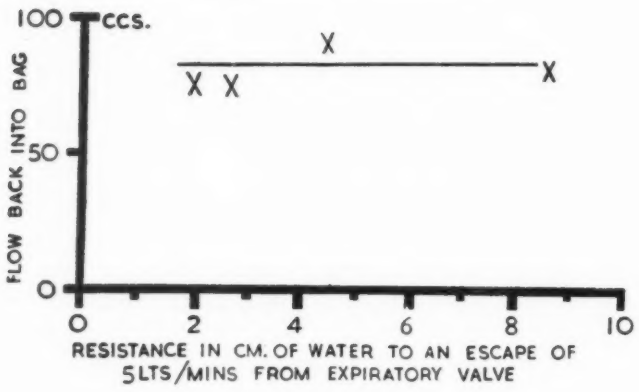

FIG. 9
The effect upon back-flow into the reservoir bag of tightening the expiratory valve

valve is rather a complicated thing, difficult to express quantitatively. It is here expressed as the pressure needed to force gas through the valve at 5 litres per minute.

DISCUSSION

Since the experimental results, using practical apparatus, agree with the rather simple mathematical predictions, it seems justified to plot the graph shown in figure 10. Here, the formula has been used to predict the rate of gas flow through the flow meters needed to limit the "back flow" to 150 ml. at each respiration, for various tidal volumes and at a rate of 25 respirations per minute.

If it is desired that the patient should not rebreathe gas containing carbon dioxide, then presumably only gas which has *not* come into contact with the alveolar membrane may be permitted to flow back toward the bag. For purposes

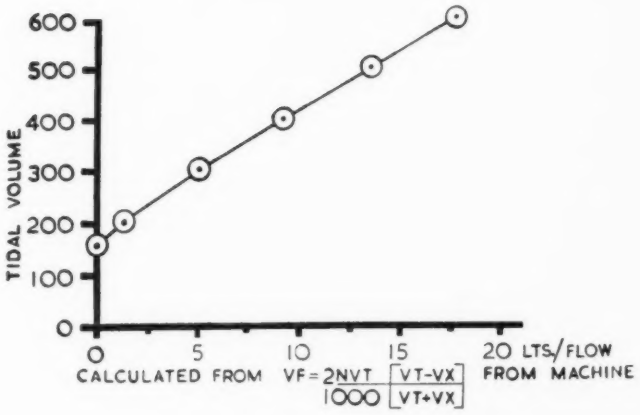

FIG. 10

The necessary rate of flow of fresh gases needed to limit the back-flow into the reservoir bag to 150 c.c. at each exhalation. The curve is plotted for various tidal volumes at the rate of 25 respirations per minute.

of example, 150 ml. has been chosen for the volume of the " physiological dead space ", but other curves could readily be calculated for any chosen figure.

It is not our purpose to discuss the disadvantages or advantages of the rebreathing of " utilized gas ". It is clear from the graph, however, that some such rebreathing will occur at, for example, a tidal volume of 500 ml., and a respiratory rate of 25 per minute, unless the flow of gases from the flow meter is of the order of 14 litres per minute. Such figures, we believe, are quite common during light anæsthesia with nitrous oxide, oxygen and ether. On the other hand, if the tidal volume falls to 350 ml. (when some anoxia may threaten) a flow of 8 litres would suffice to eliminate rebreathing of " utilized gas ".

These figures for the necessary volume of fresh gases may be higher than those usually accepted, but it seems clear that if they are not reached or exceeded, some rebreathing of " utilized gases " must occur. Whatever may be anæsthetists' views on the presence of carbon dioxide in the inhaled gases, two observations will probably be acceptable widely. Firstly in critical operations, for example cranial surgery or fenestrations, very considerable gas flows (15 litres per minute or more) must be used before one can be confident that rebreathing is eliminated when a semi-closed system is used. Secondly if hyperventilation has already set in due to carbon dioxide retention, very considerable gas flow may be needed to eliminate rebreathing at the high tidal volumes prevailing. In other words, if, for example, a flow of 5 litres per minute has been used with a tidal volume of 400 ml., some rebreathing will occur and, as a result, hyperventilation. A flow of 8 litres per minute might have been enough to prevent the difficulty but now that hyperventilation has set in, and the tidal volume becomes, let us say, 600 ml., 18 litres flow per minute may be necessary to restore the situation.

APPENDIX

Case " A " when $\alpha = 1$

The system is defined by the bag, the pipe to the mask and the mask itself.

The following assumptions will be made:

1. Respiratory pattern is of square form (fig. 11).
2. The expiratory valve closes as soon as inspiration begins.
3. Over a number of respirations, the system is in equilibrium.
4. At the end of inspiration gas has to be supplied to the system to bring it back into equilibrium. This gas will come partly from the lung and partly from the anæsthetic machine. It is assumed that the quantity of gas supplied by each source will be proportional to its rate of flow.

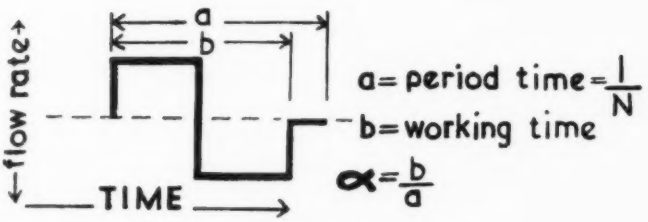

FIG. 11

Formalized respiratory pattern used for calculation

5. The system works at constant pressure.

Then let VT = tidal volume in litres.

VF = flow from anæsthetic machine in litres/min.

N = number of respirations per minute.

Consider the system at the start of inspiration.

Let the quantity of gas it contains be VO litres. At the end of inspiration the quantity of gas in the system will be

$$VO - VT + \frac{VF}{2N} \text{ litres (See assumption No. 2.)}$$

For the system to remain in equilibrium a quantity of gas equal to $VT - \frac{VF}{2N}$ must be supplied before the start of the next inspiration.

This gas can come (a) from the anæsthetic machine.
(b) from the lung.

From assumption No. 4 the lung will supply $\frac{2NVT}{2NVT + VF}$ of the total gas required.

This gas will be the returned volume VX.

$$\text{Therefore, } VX = \left\{ VT - \frac{VF}{2N} \right\} \frac{2NVT}{2NVT + VF}$$

Case "B" when α is less than unity.

If there is a pause in the respiration, then it is further assumed that equilibrium is reached at the end of expiration. This reduces the effective flow from the anæsthetic machine to αVF, so that

$$VX = \left(VT - \frac{\alpha VF}{2N} \right) \left(\frac{2NVT}{2NVT + \alpha VF} \right)$$

POST-ANÆSTHETIC GRANULOMA OF THE LARYNX

By G. A. MOULDEN *and* R. L. WYNNE

GRANULOMA of the larynx following tracheal intubation was first described by Clausen in 1932, and from time to time 13 other cases have been reported in detail by various observers (Gould, 1935; Cohen, 1938; Smiley, 1940; Farrior, 1942; Kearney, 1946; Tuft and Ratner, 1947; Barton, 1947; McLaurin, 1948; Hill, 1948; Wattles, 1949; el Mofti, 1949), besides a group of nine mentioned by New and Devine (1949), and " one or two " somewhat vaguely referred to by Lundy (1942).

The cases hitherto described are summarized fully in a thesis by Wattles (1949), and consist of similar conditions, mostly unilateral, but some bilateral, following widely divergent types of operation in which tracheal tubes were used. The durations and anæsthetic agents used vary widely, and the reported ease with which the tubes were introduced also varies from simple blind intubation to repeated attempts almost certainly involving some trauma.

In nearly every case the earliest symptom of the lesion was hoarseness, observed at intervals varying from a fortnight to six months after the operation, and in two cases dyspnœa and cyanosis presented a surgical emergency.

On laryngoscopy, the lesion, a small mass of granulation tissue, appears attached usually to the posterior portion of the vocal cord, or to the vocal process of the arytenoid

cartilage. Four cases have been described in which it was bilateral. The granuloma tends to become pedunculated as time goes on, and Kearney (1946) suggested that this might be due to a combination of outgrowing granulation with an ingrowing healing edge, which in time would eventually amputate the pedicle. This may have occurred in Clausen's case, where, after six months, the little mass was coughed up (but biopsy showed only blood-clot with early organization). The condition is cured by simple removal, opinions on the use of diathermy being divided (Jackson and Jackson, 1935; Howard, 1938). In some cases there have been recurrences, which have in turn finally responded to removal.

Pathologically the tumour consists of non-specific granulation tissue, having the usual features of new blood-vessels, mononuclear cells, polymorphonuclear cells, lymphocytes, plasma cells and fibroblasts. (It is intimately related to the "contact ulcer" granuloma described by Jackson in 1928, which is caused through trauma by the tip of the vocal process on the opposite cord, and of which an association with respiratory tuberculosis has been suggested by Johansen and Kiaer (1949).)

CASE HISTORY

We have been fortunate in having the case here described under observation both before operation and over a considerable subsequent period.

The patient, a woman of 43, was referred by her doctor for surgical opinion in June 1948, on account of a thyroid swelling and associated toxic symptoms.

On examination she was found to have a smooth, soft, mobile enlargement of the right lobe of the thyroid, which was pressing the trachea to the left; and a slight enlargement of the left lobe. Some swelling had been present for as long as 18 years, but during the last six months she had had a choky sensation and

been inclined to lose her voice. In appearance she was pale and overweight. Her pulse was 120/min., and her blood-pressure 160/95 mm. Hg. She had occasional palpitation but could walk uphill without great discomfort. She sweated easily, preferred winter time, and said her appetite was poor and her nerves bad. No exophthalmos was found, but she had a tremor described as coarse rather than fine.

When she was seen by the laryngologist on 22nd June 1948, it was noted that her present complaint was of losing her voice a fortnight before, and of persisting hoarseness. Examination showed both antra clear on transillumination, both nasal fossæ clear, some tonsil rests from an operation in 1946, but no glands. In particular, her vocal cords were inspected and found normal in appearance and movement. The cavity of an old right radical mastoid operation was still moist and was cleaned up. On examining her previous records she was found to have attended in July 1946 for œsophagoscopy on complaint of having swallowed a fish-bone. Nothing at that time had been found except a small puncture mark at the œsophageal entrance. On consideration of the history and present findings the opinion was formed that the aphonia of which she complained was functional in itself, though associated with a separate organic condition.

She was assessed by a physician as having a low grade of thyrotoxicosis, for which pre-operative iodine treatment was recommended, but no thiouracil. Her blood-count disclosed 5.2 million red cells and 12,000 white cells per cubic mm., other features being within normal limits. Her blood contained 114 mg. per cent cholesterol.

Right hemithyroidectomy was carried out on 7th July 1948. Before operation her temperature was found to be 97° F., her pulse 92/min., respiration 20/min., and blood-pressure 160/95 mm. Hg. After premedication by papaveretum gr. ¼ (16 mg.) and hyoscine gr. 1/200 (0.3 mg.), anæsthesia was induced by injection of 0.5 g. of thiopentone in 5 per cent solution. No. 3 Guedel airway was then inserted, and anæsthesia continued by nitrous oxide, oxygen, and ether. An ordinary soft Magill tracheal tube, size 7, which had been stored in a clean dry condition and not treated with antiseptic, was boiled for two minutes, lubricated with sterile liquid paraffin, and passed through the right nostril by the blind technique. No difficulty was encountered. The pharynx was then packed with a wet cotton bandage, and anæsthesia maintained by ether and oxygen with carbon dioxide absorption. Anæsthesia had perhaps been started too soon during the previous operation on the list, since the surgeon was not free to commence this operation until anæsthesia had been continued thirty minutes. During operation the shoulders were

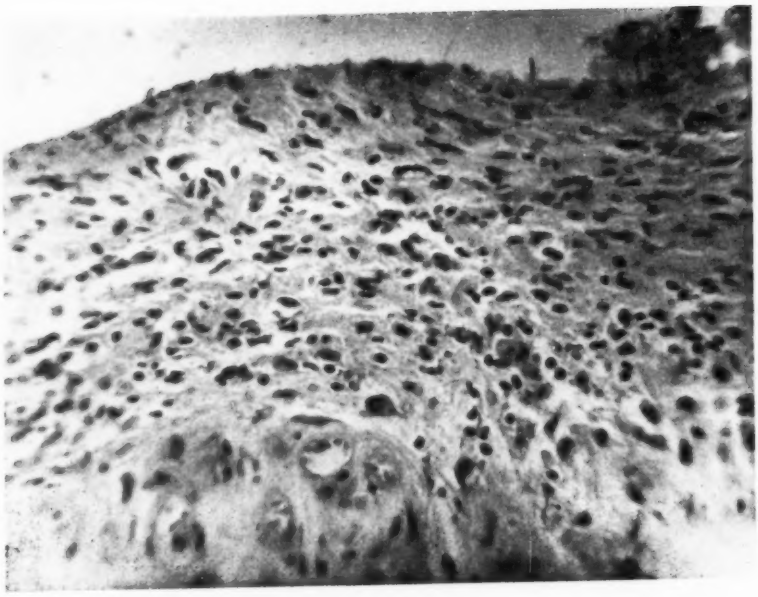

FIG. 2
Section of granuloma under low magnification

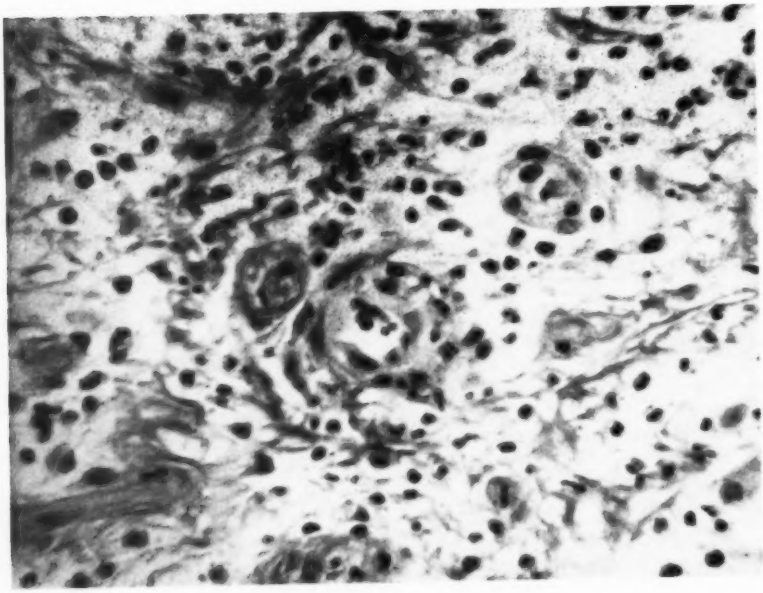

FIG. 3
Section of granuloma under high magnification

elevated on a sandbag, and the head maintained in full extension. The operation took longer than usual on account of an unusual vascularity of the tissues, and was completed one hour and fifty minutes after induction of anæsthesia.

Recovery after operation was uneventful except for the aspiration of a small collection of blood-stained fluid from the wound before her discharge ten days later. Section of the tumour confirmed the diagnosis of thyroid adenoma. Blood examination was repeated on 15th July, and showed the red cells to have fallen to 5.08 million per cubic mm., with slight anisocytosis, but no other noteworthy feature.

She presented herself again to the laryngologist on 2nd November 1948, complaining of loss of voice, varying in degree from day to day. Examination showed a pale, round, slightly dimpled subglottic mass near the posterior extremity of the left vocal cord. (Fig. 1.) Two days later the mass was removed

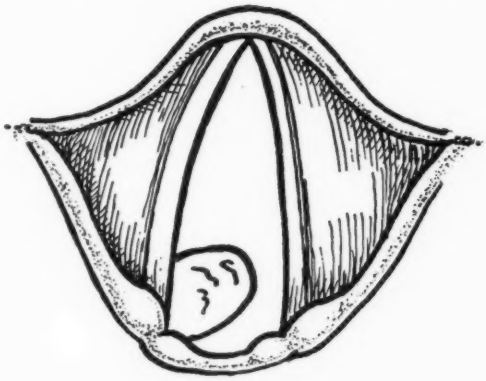

FIG. 1

Sketch of laryngoscopic appearance, 2nd November, 1948

by direct laryngoscopy, examination on the following day confirming that the cords were now normal in appearance and movement, and that no remains of the tumour were to be seen. Laryngoscopy was again performed on 23rd November 1948, and verified the normal appearance of the cords. The appearance of the section may be seen in the photographs (figs. 2 and 3), and it was reported by the pathologist as a granuloma of recent origin.

When she was seen again in April 1950, the patient was symptom-free and had no sign of recurrence.

DISCUSSION

The device of a stream of air carrying ether vapour via a tracheal tube to a region near the bifurcation was first used in animals by Meltzer and Auer in 1909, and soon afterwards adopted for surgical use in humans by Elsberg (1910). It had many advantages, and opened up new fields in surgery; but of recent years it has almost entirely given way to endotracheal inhalation, a method described by Magill in 1928 (though he first used it as early as 1920), and by Guedel and Waters in the same year, when they published a photograph of a tube bearing considerable resemblance to the cuffed types now in wide use. This latter had been evolved in their studies of cyclopropane, with its corollaries of carbon dioxide absorption and a closed inhalation system.

Both methods, though exhibiting considerable difference in physiological mechanism, are referred to as tracheal, or endotracheal, intubation. (The word " intratracheal ", of hybrid derivation, should be dropped.) One of the most important differences is in the calibre of the tube used. In the earlier method of insufflation it is important that the tube should not exceed half the diameter of the trachea, in order to allow an external return stream; but with inhalation methods it is on the contrary important that the tube should be as wide as the trachea can tolerate, in order that the normal to-and-fro movements of respiration can take place through it with negligible resistance. Chevalier Jackson investigated the question of tracheal diameter, and in a personal communication to Flagg concluded that a man's larynx would admit a tube of

$12\frac{2}{3}$ mm. diameter, and a woman's one of $10\frac{2}{3}$ mm. (sizes 38 and 32 by the French scale) (Flagg, 1944). Length is necessary in the insufflation tube so that the conveyed gases are liberated near the bifurcation. With the inhalation tube shortness is desirable, so that, once the tube is past the cords, as much as possible of the tracheal mucosa is available to humidify the gases.

In the earlier days of insufflation Jackson (cited by Flagg, 1944) followed up a number of cases, and felt able to announce that "there is no reaction in the larynx from the presence of the insufflation tube even in prolonged anæsthesia", and he was prepared to add that "there is less irritation in the larynx from an intratracheal insufflation tube than from an anæsthesia of corresponding duration by the open method". The subsequent widespread use of the larger bore tube dates from 1928, and it is perhaps not entirely coincidental that the cases of granuloma commence to be recorded from 1932.

The popularity, however, of the Magill tube is soundly based on numerous advantages it offers: normal respiration, a patent airway requiring no especial manipulation to preserve its patency, protection of the air-passages from insufflation of foreign material from the pharynx, the possibility of posturing the head in ways which otherwise would cause obstruction, the removal of the anæsthetist and his apparatus from the field of operation, and immediate control of respiration while avoiding inflation of the œsophagus and stomach with anæsthetic gases.

As to the causation of granulomata, many factors have been postulated. New and Devine (1949) pointed out the preponderance of women in post-intubation cases, as contrasted with the fact that contact ulcer occurs in nearly 100 per cent of the cases in men. All the reported cases

appear to have been of adult age. Lundy (1942) suggests the influence of a general intolerance of the mucous membranes, and cites a case where tracheitis followed intubation and urethritis followed catheterization in the same patient.

Infection from without might favour their occurrence, but tubes are usually sterilized before insertion. Chemical trauma from antiseptic solution used for sterilization of the tube and not entirely washed off might be a possible cause, but there is nothing in the details published to indicate its occurrence. Similarly a tube boiled and insufficiently cooled might be a source of trauma. The traumatism of a dry tube is so universally recognized that it must be very rare for an unlubricated one to be used except in an emergency.

The possibility of auto-infection from the nasal passages, especially during extubation over a previously damaged surface, has been surmised, and a large survey of intubations in America showed a higher incidence of minor respiratory sequelæ after nasal than after oral intubation (Hewer, 1948). Nevertheless, it is common experience that blind nasal intubation in practised hands is a facile technique, causing less disturbance and often less likely to cause trauma than laryngoscopic manipulation. The available records do not make it clear in many cases whether nasal or oral tubes were used.

The depth of anæsthesia is obviously important. Gould (1935), describing the second recorded case, condemns the practice of pushing the tube against a closed glottis (though the essential trauma appears to be to the tip of the vocal process, *after* introduction), or over-manipulating it with the head in a faulty position, or anæsthesia insufficiently deep for relaxation. It would seem equally bad

to allow lightening of anæsthesia during the operation, or to allow the tube to remain *in situ* after operation when reflexes have returned. However, many years ago, when nursing personnel were less familiar with intubation, one of the writers (R. L. W.) saw a nasal tube removed from an elderly man some 48 hours after operation without any apparent ill consequences.

The shape of the bevel may be important. In the traditional pattern of the Magill tube the bevel is cut sideways, so that the first portion of the tube to reach the larynx is a single thickness of rubber in the sagittal plane, forming the thin end of a wedge, which once engaged in the glottis easily finds a passage for the rest of the tube. If the single thickness thus encountering the larynx is of hard rubber and insufficiently rounded it may present a blunt knife-edge capable of wounding. This possibility, however, must be remote, otherwise one would expect to find a proportion of granulomata in other than the characteristic site.

The rubber of which the tube is made should be soft enough to be yielding, but not so soft as to collapse and so stultify the object of its use. Tubes which are repeatedly boiled vary during their useful life both in calibre, which grows larger (irrespective of the number they bear), and in softness, which increases with age and boilings. Such variation counsels individual scrutiny of each tube used.

Pre-existing disease of the larynx would usually cause the abandonment of any intention to use a tube, though the case described above has the feature of a pre-existing functional aphonia.

Thyroid operations, of which no fewer than 3 occur in the small series of 13 cases, attract attention by reason of the increased hazard offered by associated tracheal de-

formation and softening, the position of extreme extension, and the unavoidable handling and stretching of the parts.

Curvature of the tube is convenient for blind insertion, but in the extended position of the head the tube is recurved, and by its elasticity must cause continued pressure, and consequent ischæmia, in the posterior parts of the glottis, with added friction on respiration, and when movements of the head and neck take place. Such movements may be caused by placing the patient in position for operation, by manipulation of the trachea during thyroid operations, or by reflex swallowing, retching or coughing. The radiograph of an extended head with an oral tube *in situ* (fig. 4) displays the tube somewhat recurved and pressed on the back of the larynx to a slight degree. That (fig. 5) of an extended head with a nasal tube shows a great increase in the recurvation, and consequently in the backward pressure. It is notable that the lesion commonly occurs in the posterior parts of the cords; and the use of a pharyngeal pack in the case described, around and in front of the tube, must have favoured posterior pressure. The use of an inflatable cuff would have been better.

The use of a tube in thyroid operations has been condemned by some anæsthetists, but it is our opinion that the protection it affords to the airway during prolonged manipulation, traction and deformation of the otherwise unsupported trachea is an advantage not lightly to be surrendered, while recognizing that special caution and gentleness must be the rule. The obvious spring-like pressure of the deformed curved tube in operations involving an extended neck, and the possibility of infecting a damaged surface by nasal flora, suggest the use in such cases of a less curved or nearly straight oral tube, and the abandonment of time-honoured "blind" methods.

FIG. 4

Radiograph of extended head with oral tube, showing slight recurvation of the tube, which is not sufficient to compress the larynx against the vertebral column

FIG. 5

Radiograph of extended head with nasal tube. The tube is much recurved, and the larynx is shown firmly compressed against the vertebral column

SUMMARY

A case of granuloma of the larynx following intubation for a thyroid operation is described, and the causation of the condition discussed.

It is concluded that so rare and benign a lesion, which is readily diagnosed and treated, cannot be held to contra-indicate intubation where necessary for the success of the operation, as long as vigilant precautions are taken against trauma and infection.

In particular, the combination of a large-bore *nasal* curved tube with an extended neck should be avoided, especially in cases of goitre, in which some deterioration in nutrition of the upper air-passages is to be expected, and in which some mechanical traction on them is almost inevitable. In such cases an oral tube should be employed, and if any additional obturator is necessary the use of a pharyngeal pack should be eschewed in favour of an inflatable cuff.

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A COMPARATIVE REVIEW OF THE RELAXANTS*

By CYRIL F. SCURR

"THE great inconvenience of light general anæsthesia during abdominal operations is that the patient's muscles become tense, making closure difficult. Because of this fact, anæsthesia must often be deepened in the final stages of the operation, and this may lead to the danger of overdose." So wrote Laewen of Leipzig in 1912. He continued—"I have attempted to prevent this abdominal tension by other means, and used curarine, a pure active substance produced by Boehm; exact doses of this can be given with reliability. With this drug an evident and satisfactory effect was produced for suturing the abdominal walls. By restricting inhalation anæsthesia we lessen an important factor in the ætiology of complications. The good physical condition of patients after operation is the best evidence of the efficacy of the method."

Such enlightened observations unfortunately attracted little notice at the time, and owing to shortage of supplies of the drug Laewen's work was curtailed.

Apart from Ranyard West's classical work on the use of curare extracts in tetanus published in 1935, and the isolation at the same time, also in this country, of pure crystalline d-tubocurarine chloride by King (1935), no further clinical application of the drug was described for nearly thirty years.

* Based on a paper read before The South West Metropolitan Regional Society of Anæsthetists, on 21st October, 1950.

In August 1939 Palmer (1950) in England and in 1940 Bennett of Nebraska employed intravenous injections of curare derivatives for the prevention of trauma during electroconvulsive therapy. In 1942 Griffith (Griffith and Johnson, 1944) first used Intocostrin as an aid to anæsthesia in Montreal.

In 1944 and 1945 larger supplies became available in this country and papers on the use of d-tubocurarine as a relaxant in anæsthesia were published by Gray and Halton (1946), and by Prescott, Organe, and Rowbotham (1946).

Since that time d-tubocurarine (or D.T.C.), first isolated here by King (1935), has been joined by other relaxant agents.

Myanesin was introduced by Berger and Bradley (1947), and C.10 or decamethonium iodide by Paton and Zaimis (1948). There followed the dimethyl ether of d-tubocurarine iodide synthesized by Collier (1948)—all these three drugs in this country. In France careful and systematic research by Bovet (1946) led to the introduction of Flaxedil. In America the biologically standardized extract Intocostrin was slowly being displaced by the pure crystalline substance d-tubocurarine chloride.

To judge from the anæsthetic literature of the last five years—as well as the introduction of new agents—clinical application, too, has made much greater progress on this side of the Atlantic. However, the number of possible curarizing compounds is legion; there is still opportunity and it is highly probably that new ones with definite clinical advantages over our present agents may be introduced.

In this paper a comparison is made of some features in the action of these various drugs.

Potency

There is a very great degree of species variation apparent in the action of the various curarizing agents. For example, dimethyl ether of d-tubocurarine iodide was found by animal experiment to be more than six times as powerful weight for weight as d-tubocurarine chloride (Collier, 1950) and it seemed that a simple chemical process could make our supplies go six times as far in times of shortage. However, clinical experience in man showed that dimethyl ether of d-tubocurarine iodide is only about two to two and a half times as potent as d-tubocurarine chloride.

Clinically equivalent doses to 15 mg. of d-tubocurarine chloride in man may be listed roughly as follows:

decamethonium iodide	3–4 mg.
dimethyl ether of d-tubocurarine iodide	6–7½ mg.
Flaxedil	100–120 mg.

At this point one must add a caution. Decamethonium iodide has become available, in the U.S.A. at least, in the form of salts other than the iodide—perhaps the iodide was an unhappy initial choice in view of possible side effects of the iodide ion. However, 1 mg. of decamethonium as chloride is equal to 1.6 mg. of the iodide salt, the form to which we are accustomed. The larger molecules of tubocurarine derivatives are, however, scarcely affected as regards dosage by this chloride/iodide difference. Perhaps the best procedure may be to state dosage with reference only to the weight of curarizing ion.

Effects on Respiration

There is a great difference of opinion as to whether adequate abdominal muscular relaxation can be secured

whilst avoiding depression of the muscles of respiration—each new drug, decamethonium iodide, dimethyl d-tubocurarine, and more recently Flaxedil, has been claimed to have a respiratory sparing effect when compared with the veteran d-tubocurarine. The importance of this has been over emphasized, because some assistance to the respiration should always be provided when a relaxant is given. However, in unskilled hands respiratory sparing would presumably imply a greater safety margin.

At first sight it seems odd that such an effect should be possible since the nerve supply to the abdominal muscles is the same as that of a major portion of the intercostals—paralysis of one group should be accompanied by paralysis of all muscles similarly innervated. However, the situation is not quite so simple and the claim of respiratory sparing for decamethonium iodide is based on the following sound experimental evidence in the cat: "Respiration is essentially a repeated brief tetanus of a red muscle (the diaphragm). It is therefore only to be expected that respiration should be depressed more by d-tubocurarine (which selectively paralyses red muscle and depresses tetanus very strongly) than by decamethonium iodide which spares red muscle, and allows a tetanus to be well sustained." (Paton, 1949.) However, circulating adrenaline reduces this red–white muscle difference in the action of decamethonium iodide, and species variation further reduces the respiratory sparing effect in man; so that Unna, et al. (1950) found that equipotent doses as judged by 95 per cent depression of hand-grip strength reduced the vital capacity as follows:

dimethyl d-tubocurarine	by 14 per cent
d-tubocurarine	by 31 per cent
decamethonium iodide	by 59 per cent

So that decamethonium iodide finds itself at the bottom of the list—however at this point the question of muscle specificity crops up, that is to say that equipotent doses in respect of depression of forearm muscles may bear no relation to the comparable figures for equal depression of abdominal muscles, which are believed to be much more favourable to decamethonium iodide.

A further point—Unna's figures were obtained from experiments on conscious subjects whose high circulating adrenaline would, as already noted, be unfavourable to the respiratory sparing effect of decamethonium iodide. However, this point of muscle specificity does mean that respiratory sparing can be a clinical possibility and, for example, Flaxedil appears to produce good relaxation of jaw and laryngeal muscles with minimal respiratory depression (Doughty, 1950).

Despite the experimental work, pneumographic observations, made in conjunction with Davies and Lewis (1949) during electro-convulsive therapy in man, showed that abdominal and thoracic respiration failed together with decamethonium iodide, and also restarted together as its effect passed off.

In the case of d-tubocurarine, diaphragmatic respiration persisted longer than the thoracic component. It should also be added that during this series no patient noted any difference in symptoms arising from decamethonium iodide and d-tubocurarine.

Hewer, et al. (1949) stated that relaxation comparable to that of d-tubocurarine could only be obtained with doses of decamethonium which paralysed the muscles of respiration. Organe (1949) noted that in some cases the tone of the abdominal flank muscles persisted with decamethonium iodide as long as the respiration and added that in such

cases it might be necessary to paralyse the respiration to obtain satisfactory conditions for closure.

In the writer's own experience, confirmed by Harris and Dripps (1950), there is little or no qualitative difference between the relaxation obtained from adequate doses of decamethonium iodide, d-tubocurarine or dimethyl d-tubocurarine. For those who say that the relaxant effect of decamethonium iodide is inferior, it must be pointed out that its action is very short lived and the limitations of the drug may be blamed for the tightness when in reality its action is passing off. Other factors than the decamethonium iodide may be responsible for the respiratory depression or apnœa which may coexist.

Effects on the Circulation

With regard to heparin and histamine release, d-tubocurarine compares unfavourably with the other agents (Organe, 1949; Bulbring and Depierre, 1949), so that with them one might expect less bleeding and a lower incidence of hypotension and broncho-constriction.

In respect of ganglionic blocking activity d-tubocurarine is considerably more powerful than the other agents. To those who believe that this action is responsible for the absence of autonomic reflexes in curarized patients and for the absence of shock despite very light anæsthesia, this might indicate that severe circulatory disturbances would be frequently encountered with other relaxants. Clinically this does not occur and it is possible that the common factor, myoneural block, by the prevention of reflex protest on the part of the voluntary musculature (especially of thorax and abdomen), accounts for the level blood pressure charts usually seen where relaxant and light anæsthesia are skilfully administered.

Flaxedil has a peculiarity of its own in its effect on the cardiovascular system. A tachycardia almost invariably follows the administration of this drug. This is probably due to an atropine-like action. The rise in pulse rate is not often gross, but it is rarely below 100 per minute during anæsthesia in which Flaxedil has been employed. No harm seems to result from this effect, but one feels, at least, that it is a bad start and may imply a reduced circulatory reserve.

Effects on the Uterus

d-Tubocurarine is said to increase uterine tone and to cause contraction of the uterus near term. For this reason its use for external version has been condemned. I have used decamethonium iodide for the purpose in conjunction with thiopentone, with very successful results in 30 cases. From experience of the use of both these agents for Cæsarean section, the bleeding does not seem to differ and the condition of the uterine muscle appears similar.

The pressure of liquor amnii in the uterus during Cæsarean section has been measured in two patients, in one decamethonium iodide was given and in the other d-tubocurarine. No rise in liquor pressure was seen in either case following the administration of relaxant—in fact, there was a fall in both. This limited experiment, which should be repeated, certainly does not support the rather vague and unsubstantiated reports of an oxytocic effect of d-tubocurarine.

In connection with Cæsarean section it is of interest to observe that although it was feared that the small molecule of decamethonium iodide might pass via the placenta into the fœtal circulation, there is abundant clinical and experimental evidence that this does not occur

(Young, 1949). Both decamethonium iodide and d-tubocurarine are safe to use for this operation.

Duration of Action

The most obvious difference of great clinical importance becomes evident when the relative duration of action of these relaxants is studied. Clinical experience is as follows:

decamethonium iodide	15–20 minutes
Flaxedil	25–30 minutes
dimethyl d-tubocurarine	30–40 minutes
d-tubocurarine	30–45 minutes

Despite some reports of variations, the maximal effect of all these agents is manifest 3–4 minutes after intravenous administration. Any other result would be surprising, for despite differing modes of operation, the *site* of action is the same in every case—namely, the myoneural junction.

The Effect of Subsequent Doses

In the case of d-tubocurarine, a second dose half the size of the first and given 45 minutes afterwards produces curarization of the same degree as the initial injection (Pelikan, et al., 1950).

With decamethonium iodide, however, tachyphylaxis or increasing resistance is encountered when further doses are given—a second dose given 30 minutes later has to be slightly greater in quantity to produce as great an effect as the first; this implies that cumulative action is absent with decamethonium iodide.

Mixed Effects

A dose of d-tubocurarine given during the action of decamethonium iodide will have an enhanced effect, but

if decamethonium iodide be given to a patient already partly curarized with d-tubocurarine its effect will be much less than expected.

Striking prolongation of the action of d-tubocurarine can be encountered in cases of idiosyncrasy—probably all these individuals are subclinical myasthenics. In them the action of d-tubocurarine is excessive in both *degree* and duration. Probably such cases can be spotted by means of a test dose.

The question of a similar possibility arising with decamethonium iodide is obviously of importance; the search for two years for a myasthenic volunteer to decide this question, has so far been unsuccessful. It seems unlikely that decamethonium iodide will have an enhanced effect in myasthenics.

Some cases of apparent prolonged action of decamethonium iodide have been reported; most of them do not display an excessive degree of paralysis from decamethonium iodide—respiration returning after each dose—but intercostal activity is greatly impaired at the end of operation (Hunter, 1950; Gray, 1950; Harris and Dripps, 1950).

Pentamethonium iodide, the pharmacological antidote to decamethonium iodide, is generally contra-indicated and ineffective in these patients. In 1949 the use of pentamethonium iodide as a hypotensive agent was introduced by the writer (*cited by* Organe, 1950) to reduce bleeding during certain operations, but at the end of a long procedure this side effect may lead to the gravest results.

Prostigmine does not antagonize decamethonium iodide, but, as shown later, in theory it may increase the harm. However, a colleague has given it in this emergency on more than one occasion with successful results—it may be

that the depression was not due to the decamethonium iodide and possibly that the Prostigmine acted as a non-specific general stimulus. He has also described a case of delayed effect of Flaxedil lasting 13 hours which was finally reversed by Prostigmine (Fairley, 1950).

It is by no means easy to obtain convincing evidence that idiosyncrasy to decamethonium iodide really exists—a small test dose cannot be expected to provide any guide—this question is most important to the future use of the drug—two series each of over 1,000 cases have been investigated without any such variation being encountered.

Apart from pentamethonium iodide, d-tubocurarine and ether also antagonize to some extent the paralysing effect of decamethonium iodide. This is surprising, especially as ether reinforces the curarizing effect of d-tubocurarine. This question of antagonism indicates that the mode of action of d-tubocurarine and decamethonium iodide on the myoneural junction is different. This difference is so fundamental that logically one should drop the use of the term "curarizing" or "curariform" when referring generally to the action of the relaxants—unhappily the accurate alternative, "myoneural blocking agents" is a cumbersome pedantry.

The accepted explanation of the mechanism of transmission at the myoneural junction is somewhat as follows. The arrival of the motor nerve impulse leads to the liberation of acetyl choline, this substance depolarizes the motor end-plate (i.e. that part of the muscle where the motor nerve fibre ends on the muscle membrane). Accompanying this an electric current known as the action potential is generated and it is by means of this end-plate potential that excitation of the muscle fibre occurs.

It is obvious that this sequence of events cannot be

repeated until repolarization occurs (i.e. the establishment of a negative charge at the surface of the axon and muscle membrane). For this, it is necessary to remove the acetyl choline and this is done by hydrolysis by cholinesterase, usually in the few thousandths of a second corresponding to what is called the refractory period. It is evident that if the acetyl choline could be made to persist, e.g. by opposing its destruction, which can be done by means of a suitable dose of physostigmine, then the depolarization would also endure, implying that the muscle would be inexcitable or paralysed. The paralysing action of decamethonium iodide is precisely analogous to such an effect of acetyl choline; it depolarizes the muscle membrane, rendering it inexcitable for a 2–3 mm. zone at the end-plate (Paton and Zaimis, 1950; Paton, 1950).

Several conclusions follow:

1. The initial depolarizing effect of injected decamethonium iodide corresponds to the normal event in a motor stimulus—so that one does see at the onset with this drug some inco-ordinate motor effects—twitches, fasciculation, etc. In fowls this effect predominates and convulsions occur.

2. A small test dose, e.g. 1 mg. of decamethonium iodide, might give misleading results on account of this motor effect, which is greatly enhanced by circulating adrenaline such as is likely to be plentifully available in the conscious patient.

3. Drugs such as Prostigmine, which cause acetyl choline to persist, so far from antagonizing decamethonium iodide, may actually increase its paralysing effect.

Curare acts in a contrary manner—it prevents the initial depolarization of muscle by acetyl choline, thus interfering with the transmission process. One might

suppose that curare would prevent this action on the part of decamethonium iodide as well, and this is indeed the case, for d-tubocurarine antagonizes the paralytic effect of decamethonium.

Having seen how diametrically opposed are the modes of action of decamethonium iodide and d-tubocurarine, it is somewhat unfortunate that a recent American paper ascribed what it called the "curarizing" effect of decamethonium iodide to the fact that the new agent had two quaternary groups 15Å apart—a structure close to that of d-tubocurarine (Kimura and Unna, 1950).

Further confirmation that decamethonium iodide can be regarded as an acetyl choline that cannot be hydrolyzed, is provided by a simple examination of the chemistry.

Acetyl choline is normally destroyed by splitting the choline portion from the acetate part.

(CHOLINE | ACETATE)

If two molecules of acetyl choline be joined together by the acetate ends as follows:

Choline acetate — acetyl choline,

then the splitting off of acetate can no longer occur. Bovet has produced this compound, "diacetyl choline" (Castillo and De Beer, 1950), and it has a similar action to decamethonium iodide, but of shorter duration. Furthermore its formula is almost the same as decamethonium iodide, differing mainly in that the 10 atom chain consists of 8 carbon and 2 oxygen atoms instead of 10 carbon atoms.

So far Myanesin has merely been mentioned—it is much to be regretted that it has certain side effects which have to a great extent caused anæsthetists to abandon its use.

Its site of action, presumed to be on synapses in the central nervous system, appears to make it highly specific for the desired purpose of preventing rigidity—other effects such as depression of the respiration can be avoided (although sometimes one may wish to produce respiratory quietude). Perhaps less harmful agents of this type may be introduced —Glyketal is already being investigated.

CONCLUSIONS

The outstanding clinical difference between the various relaxant agents concerns duration of action.

The quality of relaxation obtained can be maximal with all the agents reviewed (with the possible exception of Myanesin), however, the distribution of muscular paralysis may vary somewhat from one agent to another, so that conflicting estimates of the respiratory depressant effect have been published.

The question of idiosyncrasy to the relaxants is very important; that it can be encountered with d-tubocurarine is established (Gray and Halton, 1948); a number of cases of prolonged intercostal paralysis following decamethonium iodide have also been reported. It is therefore unfortunate that there is no suitable antagonist for decamethonium iodide; such cases should be treated by intubation and artificial ventilation for as long as is necessary. In view of the fact that the action of decamethonium iodide is analogous to that of acetyl choline itself, i.e. depolarization of the muscle membrane, anti-esterase drugs such as Prostigmine should not be given to counteract its effects.

SUMMARY

1. The development of the use of relaxant agents is reviewed.

2. The potency, duration, and respiratory effects of these various drugs are compared.
3. Effects on other systems are briefly considered.
4. Idiosyncrasy and antagonism are examined in the light of recent work on the differing mode of action of d-tubocurarine and decamethonium iodide.

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ISOPROPYL CHLORIDE AS AN ANÆSTHETIC FOR TONSILLECTOMY

By JOHN LOCKETT

THE first report on the use of isopropyl chloride in anæsthesia was made by MacDonald (1950) who described its rapid action, lack of irritation to the respiratory mucosa, and quick excretion. In addition, it had apparently no side effects and, in particular, produced no marked changes in blood-pressure. This latter observation was a little surprising as ethyl chloride, its near relative, has a very profound effect on blood-pressure levels in the deeper planes of anæsthesia. However, the overall picture was attractive and, while it was noted that all the cases in MacDonald's series were adults, it was considered that this anæsthetic might be of great use as the main agent for the anæsthesia of children during dissection tonsillectomy.

Consequently, a series of fifty such cases was undertaken. The children's ages ranged from 3 to 12 years, and the anæsthetic technique used was the same for all.

TECHNIQUE

Atropine gr. 1/100 (0.6 mg.) by injection and Nembutal gr. 1½ to 3 (90 to 180 mg.) orally were given forty-five minutes before operation. Anæsthesia was induced by nitrous oxide and oxygen using a standard Boyle's machine. The isopropyl chloride had been placed in the ether bottle of the machine and was admitted to the circuit immediately after induction. The change-over was easy. Most patients accepted the vapour without any alteration

of the respiratory rhythm. The concentration of isopropyl chloride was rapidly increased. Within two to three minutes the respirations became deep and regular (resembling the respiration seen with ethyl chloride) and the jaw was relaxed. A Boyle-Davis gag was introduced and during the operation the anæsthetic mixture was insufflated through the indwelling catheter on the gag.

RESULTS

The advantages of this agent were considerable. As it is a potent anæsthetic, the induction was rapid, and the total amount of the drug used was very small, averaging 1 ounce per patient. The recovery was almost as rapid, and the patients were conscious by the time they were returned to the ward. This was a great help to a busy nursing staff. There was no excessive vomiting, and all the children were fit to return home the next day. The relaxation of the jaw and muscles of the cervical region was excellent, even when the anæsthesia was light. The fact that the drug is non-irritant to the respiratory tract and has a rapid action permits the anæsthetist who may allow his patient to become too light during operation to deepen the anæsthesia quickly and with ease. All these properties would seem to indicate that this anæsthetic should be suitable for this operation.

Unfortunately, however, this was not the whole picture. MacDonald (1950) suggested a large margin of safety. In children, the margin was almost non-existent. It was found essential to reduce the concentration of isopropyl chloride once deep regular breathing was achieved. If this was not done, the respiration rapidly ceased, and the apnœa was followed immediately by a disappearance of the pulse beat. Artificial respiration for two or three minutes,

however, restored the situation; natural breathing was resumed and the pulse became palpable.

DISCUSSION

Roualle (1950) has reported one case of cardiac arrest when isopropyl chloride was being used, and Cope (1950) had several patients who exhibited cardiac irregularities which he attributed to a reflex mechanism affecting a heart sensitized by this drug. The writer would suggest another source of danger, for his " situations " appeared to arise from the lack of margin between respiratory and circulatory depression, or indeed between moderate anæsthesia and gross overdosage.

Be that as it may, it is considered by the author that an anæsthetic agent which may produce such complications, even when it is being used with the extra care necessary for clinical trials, is not safe. These experiences have led to the abandonment of this otherwise very attractive anæsthetic.

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NOTES AND COMMENTS

We would draw the attention of our readers to the following important International Congresses.

The XIth International Dental Congress, which will take place in London from July 19th to 26th, 1952, at the Royal Festival Hall. For further information regarding registration and accommodation, those who are interested should apply to Mr. Seymour Robinson, Chairman of the Accommodation Committee, XIth International Dental Congress, 13 Hill Street, London, W.1. It is understood that the programme of scientific papers is complete and, therefore, any who may wish to take an active part in the scientific deliberation of the Congress may do so by joining in the discussions, or by presenting original communications in the form of table demonstrations and scientific exhibits, and should make an early application to Mr. G. A. Morrant, Institute of Dental Surgery, Eastman Dental Hospital, Gray's Inn Road, London, W.C.1.

Once again we would remind all who are interested of the *Twenty-Sixth Annual Congress of Anæsthetists*, which is being held in London from 3rd to 8th September of this year. Those who would wish to read papers or give demonstrations at this Congress should communicate with Dr. Ronald Jarman through the Secretary, 25 Park Crescent, Portland Place, London, W.1.

Those who are responsible for teaching and for organizing programmes of local anæsthetic societies will be interested to hear that the Imperial Chemical Industries Ltd. have now produced a Film Catalogue containing a complete syllabus of all the films produced by that Company. This may be obtained from the I.C.I. Film Library, Bolton House, Curzon Street, London, W.1, from which address also the films which are listed may be borrowed free of charge.

CORRESPONDENCE

The Editor, *British Journal of Anæsthesia.*

Sir,

Deaths under Trichlorethylene

Like many British anæsthetists, I have used trichlorethylene for some years without encountering any adverse effects, apart from tachypnœa and extrasystoles. In November 1949, two consecutive cases anæsthetised with trichlorethylene died on the table, and it is possible that the drug may be implicated in the second fatality.

Case 1

A well-built Iraqi, aged 35, was knocked down by a car. He walked about for five hours until consciousness was lost, and when admitted to hospital seven hours later was deeply comatose. The pupils were fixed and dilated, the left extensor plantar response was more active than the right, and the left cremasteric reflex was absent. A small bruise was found in the right parietal region and lumbar puncture produced blood-stained fluid. The operation of right temporal decompression was performed. A two-inch deep extradural hæmatoma was found and this was due to an extensive tear of the superior

longitudinal sinus. About two pints of blood were lost before the severe venous bleeding could be controlled. No blood for transfusion was available. The patient was premedicated with atropine gr. 1/75 (0.8 mg.) intravenously and an orotracheal tube lubricated with amethocaine paste passed with the expulsion of mucus and aspirated vomit from the trachea. Oxygen and a trace of trichlorethylene was used in the hope of controlling cough and lightened reflexes on decompression. Extrasystoles developed five minutes after the exhibition of trichlorethylene and persisted (one in three to five beats). During 45 minutes surgery the blood-pressure fell steadily from 180/90 and the pulse rose from 95 to 170, until five minutes before the end of operation he became pulseless and respiration ceased. Oxygen inflation restored shallow respiration for five minutes, when no heart sounds could be heard. Cardiac massage was performed until retinal fragmentation was observed. At post-mortem there was moderate exsanguination of tissues and vessels and a large subdural hæmatoma with intraventricular hæmorrhage under the site of the extradural hæmatoma. A small right hæmothorax and fractured rib were the only other abnormalities.

Case 2

A thin Iraqi, aged 37, of small stature, was suffering from a large fibrosarcoma around the upper end of the humerus. There was bony destruction but no skin ulceration. In a previous uneventful operation one week before, the clavicle and supraclavicular glands had been removed under thiopentone and open ether anæsthesia. There was quite severe bronchitis with copious sputum following this first stage. The operation consisted of second stage forequarter amputation and lasted thirty-five minutes. Anæsthesia comprised premedication with hyoscine gr. 1/100 (0.6 mg.), followed by 0.6 g. of thiopentone, blind nasal intubation and semiclosed oxygen and trichlorethylene. Unfortunately, the surgeon was called away urgently as the induction was completed, and anæsthesia was continued for twenty-five minutes before commencing surgery. Cough and slight reflex movement persisted in spite of a fair amount of Trilene used. The blood-pressure was steady at 110/80, and the pulse rose slightly to 100. Fifteen minutes after the commencement of the rapid removal of the limb, just at the time of cutting the brachial plexus, respiration suddenly ceased and the patient was pulseless. Manual inflation restored respiration for eight minutes but no pulse returned. As the limb was removed respiration again ceased and there was no more bleeding from

the wound except venous ooze. Controlled respiration was carried out whilst 2 ml. of 1 per cent procaine was injected intravenously. At this stage it was possible to determine by auscultation that no heart sounds were present. Cardiac puncture with 1 per cent procaine and all efforts at resuscitation were unsuccessful. At post-mortem slight left ventricular hypertrophy was found, but no evidence of myocardial disease; chronic bronchitis was present; the tissues were not severely exsanguinated and the brain was congested.

Analysis of the trichlorethylene used for these cases showed only the faintest traces of acetylene and free chloride, well within the B.P. limits of purity.

With regard to Case 1, although trichlorethylene caused extrasystoles, none was given in the last twenty minutes of operation. Progressive shock from blood loss and irreversible cerebral damage would be the simplest explanation for this death.

In Case 2 progressive onset of shock was absent. One pint of blood was given during operation and nearly compensated for the loss during surgery. The collapse was sudden and dramatic, and it is suggested that although there was no previous arrhythmia, abnormal cardiac action (e.g. paroxysmal ventricular tachycardia) was initiated by an intense neurological stimulus and moderate blood concentration of trichlorethylene (second plane, respirations thirty per minute). This abnormal cardiac action was sufficient to maintain respiration, to keep the tissues pink, and to produce slight arterial bleeding for eight minutes, until presumable cardiac arrest occurred.

The hypothesis of surgical shock being greater in light anæsthesia has been disproved. However, in the case of abnormal cardiac action, light anæsthesia may permit reflex mechanisms to operate; indeed, the firm belief in the danger of light anæsthesia *per se*, which arose in the

days of open chloroform anæsthesia, was based, perhaps erroneously, on cases of chloroform collapse from cardiac arrest. This explanation of sudden collapse under trichlorethylene is purely speculative, and any other suggestions would be of interest.

Yours faithfully,

ROBERT J. STOUT

The Editor, *British Journal of Anæsthesia.*

Sir,

Rotameters in Anæsthesia

Writing in the January 1951 issue of the *British Journal of Anæsthesia*, Dr. Rowbotham states that in 1935 Dr. Magill ". . . was able to obtain rotameters made to his own measurements in this country". Since there has, in the past, been much correspondence about the adoption of rotameters for anæsthetic apparatus, may I quote from a letter which appeared in the *Lancet*, 17th January, 1942? It was written by Mr. A. H. Trost, Director of the Rotameter Manufacturing Co., Ltd., and referred to an inquiry about rotameters from Mr. Charles King in 1932. Mr. Trost continues:

"We have no record of any further communication from Mr. King until June 1937 when we discussed with him the adaptation of rotameters to modern anæsthetic requirements. I may add that *early* in 1937 we received a visit from Mr. Richard Salt, technician to the Nuffield Department of Anæsthetics, and I accept the statement

(*Lancet*, December 6th, 1941, p. 718) that the adaptation of rotameters in a form suitable for anæsthetic apparatus was suggested by Mr. Salt."

The point at issue is not the introduction of rotameters as a means of measuring gas flows, but the adaptation of this type of flowmeter to modern anæsthetic apparatus. Mr. Trost's letter makes it clear that this occurred in 1937 at the suggestion of Mr. Salt, and not in 1935 as stated by Dr. Rowbotham.

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REVIEWS

A Synopsis of Anæsthesia. By J. ALFRED LEE. Second Edition 1950. 356 pp., 66 illustrations. Published by John Wright & Sons Ltd., Bristol. Price 15*s*.

The author is to be congratulated on the production of this handy volume, which condenses within its pages so much useful knowledge, and adequately reflects the rapidly widening scope of the subject.

Although not designed to take the place of the larger text-books, and although Lee states that the syllabus for Part I of the Diploma in Anæsthetics examination requires close familiarity with other standard works, the book contains a great deal of information on anatomy, pharmacology and physiology in relation to anæsthesia, and no candidate for Part II of the examination should be without it.

The second edition is a great improvement on the first, and additional information is forthcoming on the following sections:—The physiology of the circulation; intravenous procaine; stellate ganglion block; vagus block; thoracic sympathetic block; electrical anæsthesia; the intra-arterial injection of thiopentone and its dangers; blood transfusion; dextran; hyaluronidase; anæsthesia for surgery of the heart; trilene in obstetrics; and the choice of anæsthesia.

The chapter on muscle relaxants has been re-written and there is a new chapter on the Pre-anæsthetic Clinic.

The scope of the subject matter is wide, and to criticise adequately this book a committee of experts

would be required. The author has followed many of the suggestions made in previous reviews, nevertheless a number of points need comment. The suggestion that record cards can enable the anæsthetist to assess accurately the condition of the patient during operation is untenable because there is at present no accurate method for assessment. The chief factor in shock is stated to be a depletion of blood volume, whereas the author specifies that bad anæsthetic technique, prolonged operating time, and rough movement of the patient are causes of shock, and in these conditions the blood volume may be normal.

The number of references to other works has been increased in comparison with the first edition, but if this book is to be used to supplement the larger text-books the author should have included a great many more references.

The illustrations are clear, but "figure 63" shows poor draughtsmanship. There is considerable variety in the size of print as in the previous edition, which makes for ready reference. There are two distinct variations in the quality of the paper.

No medical library would be complete without this book, which is unique; it should be in the hands of every anæsthetist.

Lumbar Puncture and Spinal Analgesia. By R. R. MACINTOSH. 149 pp., 111 illustrations. Published by E. & S. Livingstone Ltd., Edinburgh. Price 21*s*.

It is said that certain troops did not fire at the Battle of Worcester. Accordingly an officer was appointed to enquire into their conduct. By way of defence the troops presented this officer with a document setting out forty-nine reasons for their failure to perform so customary an operation. The first was that they had no ammunition. The officer, inclined to be lazy, came to the conclusion that the others were redundant and so he might be excused from reading them.

Having read Professor Mackintosh's book, or rather, having looked at it (it is more a picture book than a text book), it was evident that of the four reasons given in the preface for presenting the book, only the fourth need be considered. It runs as follows: "My fourth reason is my desire to take advantage of the collaboration of Miss MacClarty which I have the good fortune to enjoy. Certainly I should not have embarked on this work without her help."

Of the one hundred and forty-six pages of which the book consists no less than one hundred and six are concerned with lumbar puncture and a further twenty-six with the distribution of the analgesic solution. Incidentally, it may be thought that experiments with glass spines are of very doubtful value as the thecal canal and contents much more nearly resemble a sorbo rubber sponge than a glass spine. The few remaining pages are devoted to the subject of headaches and some practical hints for beginners, for whom the book is doubtless intended and to whom it should be of invaluable assistance in the making of a lumbar puncture.

Professor Macintosh does important service in calling attention to the difference in law that there may be between the results of a badly given general anæsthetic and a badly given spinal. He says: "A paralysed patient wheeled about in a bath chair is a constant reproach and does nothing to enhance the reputation of surgeon and anæsthetist concerned. Moreover, in some cases heavy damages have been awarded although, anomalously, there would not have been the slightest prospect of this if the patient had been killed outright by a general anæsthetic badly given."

Needless to say, the print is excellent and the illustrations both numerous and beautiful. One may unhesitatingly congratulate Professor Macintosh on his choice of collaborationist.

Analgesia for Normal Childbirth. By E. H. SEWARD. 19 pp., 4 illustrations. Published by Blackwell Scientific Publications, Oxford. Price 2*s*.

Dr. Seward's booklet will add materially to the literature published on inhalational analgesia for midwifery. There is nothing more important in achieving a better understanding and practice of the subject than the right presentation of the technique. This is admirably done in *Analgesia for Normal Childbirth.* The advice given on p. 7 that "The midwife should spend a quarter to half an hour with the patient, making sure that she uses the apparatus correctly, and that she understands what the gas is meant to do", is a counsel of perfection, and an illustration of the attention given to essentials.

It would be preferable that "gas and air" should be used for the word "gas" in the various sentences describing the mixture inhaled, and there is one statement on p. 3 open to question. Most primiparæ would say that pain sensations are experienced earlier than when the cervix is half dilated.

This excellent booklet is well written, and deserves a better cover and price.

Pain and its Problems. Edited by SIR HENEAGE OGILVIE and WILLIAM A. R. THOMSON. 194 pp. Published on behalf of *The Practitioner* by Eyre & Spottiswoode (Publishers) Ltd. Price 12*s*. 6*d*.

The calibre of the diagnostician is best assessed by the way he questions a patient presenting with pain. For how long has the patient suffered? Where is the pain felt and when? What is its character? What factors influence its appearance, relief, quality and distribution? The answers to these and many other queries will often contribute more than any physical examination or instrumental findings to an understanding of the significance of pain. But if they are to be accurately interpreted a basic knowledge is necessary not only of the physiology and the physical basis of pain but also of its psychological aspects. For it is sometimes forgotten that the perception of pain, its intensity, character and localization are mental (if one is permitted in this context to think for convenience in terms of body-mind dichotomy) though the integrity of anatomical structures is essential for the perception of pain of physical origin and indeed the interruption of these structures affords a method of relieving this type of pain when its cause cannot be eradicated.

This collection of essays on "Pain and its Problems", most of which were published in a series of monthly articles in *The Practitioner*, though there are many new chapters, provides an admirable and up-to-date review of the problems of pain, physiological and clinical, diagnostic and therapeutic, physical and mental, by contributors of knowledge and authority. The editing is good, and the overlapping and inconsistencies of so many books of multiple

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authorship are reduced to a minimum, though not entirely eliminated. Chapters on the physiological and clinical aspects of pain and on its meaning and management are followed by accounts of pain as an index of disease in various systems—cardiovascular, respiratory, nervous, digestive, genito-urinary and musculo-skeletal. Analgesia in labour and dental pain receive special consideration, and pain of non-organic origin is the subject of a useful chapter. The principles of treatment are well expounded, and the difficult problems associated with the relief of pain in childhood are separately considered.

This symposium should prove valuable to general practitioners and specialists alike.

Giornale Italiano di Anestesiologia. Edited by PROF. A. M. DOGLIOTTI. 124 pp. Published by Minerva Medica, Turin. Price 400L.

The *Italian Journal of Anæsthesia* is yet another source of references for writers in this specialty. The scope of the articles contained in the number examined by the reviewer ranges from the therapeutics of pain to experimental work on morphine hyperglycæmia. It contains also a short review of first experiences with endotracheal anæsthesia. A small section of the journal is devoted to technical notes and recent work is catalogued in somewhat the same way as occurs in "Current Researches" under general headings, e.g. Physiology and Pharmacology, Local Anæsthesia, etc. A valuable section is devoted to short précis of recent publications.

The layout of the journal is pleasing, the illustrations are well reproduced and the paper is of good quality. It appears to be published quarterly and this is the sixteenth year of its publication. The number of contributions and other subject matter make it clear that this journal is one which must be watched by those concerned in research work. Clinical articles are not wanting, though in this number only four of the ten original articles are primarily clinical.

Journals of anæsthesia are not so numerous that this one can be regarded as superfluous, which is more than can be said of many medical publications.

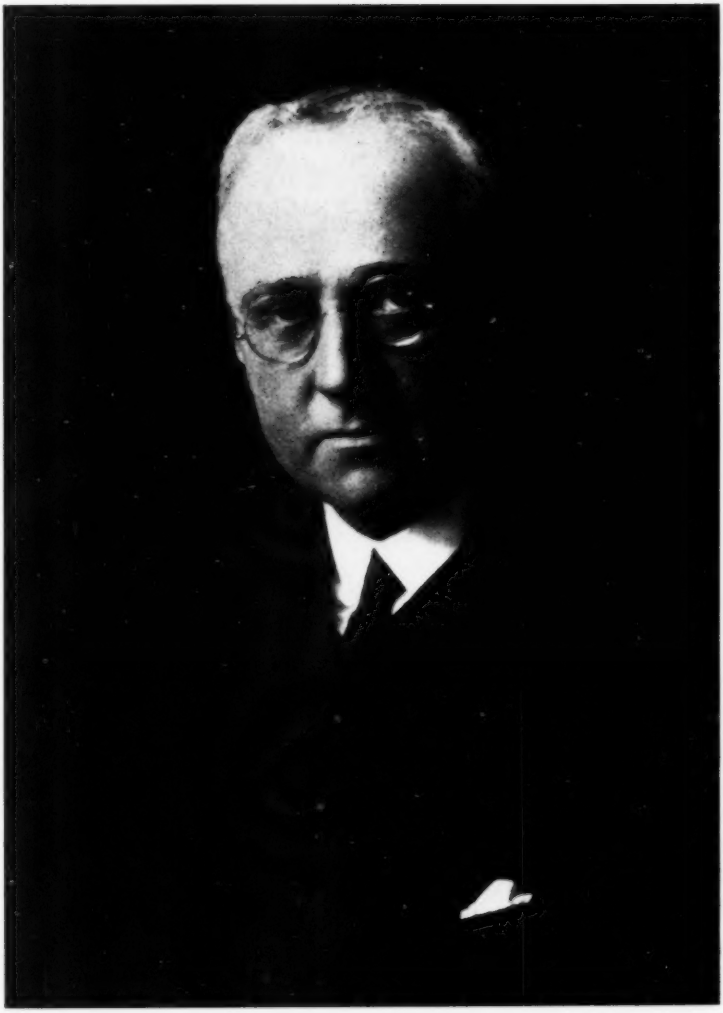
OBITUARIES

SAMUEL THOMPSON ROWLING

By R. P. HARBORD

DR. SAMUEL THOMPSON ROWLING'S death in Leeds on October 12th, 1950, in his 76th year, ends the career of one of the old school of family doctors who had a special interest in anæsthesia. Most of his life was spent in Leeds, where he was born. He was educated at the Grammar School, later studying medicine at the Leeds Medical School. He distinguished himself at the beginning of his professional life by winning the Hardwick prize in clinical medicine and by graduating M.B., Ch.B., with honours, at the Victoria University in Manchester in 1896, there being no Leeds degree at that time.

After qualification he obtained the post of house surgeon at the Leeds General Infirmary. Here it was that his interest in anæsthesia developed, an interest which was to predominate throughout his long career. At this time there were only a few men who could specialize in anæsthesia and so Rowling entered general practice. At first he had a hard time as an assistant, and it was not long before he put up his own plate. This was the beginning of a family practice which continued up to his death. In 1910 he became anæsthetist to the General Infirmary at Leeds, and subsequently obtained anæsthetic appointments to the



SAMUEL THOMPSON ROWLING

Ministry of Pensions Hospital, Leeds, and to the West Riding County Council Hospital at Otley.

He obtained the M.D. in 1920, the D.A. in 1935, and was elected a Foundation Fellow of the Faculty of Anæsthetists of the Royal College of Surgeons in 1948.

He took an active part in University life, and was for many years Honorary Lecturer in Anæsthesia. He was continually attempting to improve the methods for the administration of anæsthesia current in his day, and, realising the need for a knowledge of the concentrations of inhaled gases and vapours, he produced his ingenious chloroform paraffin bottle and his modification of Clover's inhaler. This work came to be quoted by the standard text-books and was incorporated in his thesis for M.D. The thesis began with the words, "It is the duty and privilege of every medical man to contribute something towards the advancement of his profession", and later he explains the origin of his own interest in the subject in the following way, "The subject of anæsthesia has had a special interest for the writer ever since he had a fatality whilst administering an anæsthetic for a case of empyæma which occurred in 1896, when he was a Junior House Surgeon at the Leeds General Infirmary".

At a meeting of the Yorkshire Branch of the British Medical Association held at York on November 22nd, 1911, he described an apparatus for administering the vapours of ether and chloroform with oxygen, either separately, or a mixture of any proportion, and in (approximately) known percentages for surgical anæsthesia.

The respect in which his University colleagues held him was shown by his election as Chairman of Convocation between 1924 and 1926, and later he became a member of

the University Court. He was a Fellow of the Association of Anæsthetists of Great Britain and Ireland, and in 1948 he had the honour of being the first President of the Yorkshire Society of Anæsthetists.

He invariably arrived well before the time of an operating list, and took great pains to see that all was in order before the surgeon arrived. His calm was unruffled even under the most trying circumstances. He always used his own anæsthetic apparatus, which he was constantly modifying and improving, although he was a firm exponent of the old methods with ether and chloroform.

During the 1914–1918 war he served in the R.A.M.C. At this period his services were much sought after as a result of his development of the technique of intubation using Cuhn's tube, at a time before endotracheal anæsthesia had come into being.

He had few interests outside his own family circle apart from his work, but he had a great love of ships and the sea, and many holidays took him abroad as Ship's Surgeon, often to Norway. He was a member of the Order of St. John of Jerusalem and a corps surgeon to the St. John Ambulance Brigade.

He had a charming personality which brought him many friends, and he had a ready wit and a fine sense of humour. His energy was boundless, and he never seemed to rest in the service of others.

It was a never to be forgotten stimulus to meet him in his own home, and to enjoy his hospitality. Here he saw many patients, who remained with him throughout their lives.

He was a non-smoker, a total abstainer and was deeply religious, being for many years a lay reader. The Vicar of Leeds tells a story that when he was advised by his

doctors to give up his lay readership he offered to drive in his own car any other lay reader who found difficulty in keeping an appointment. The last ten years of his life were burdened by angina, but nevertheless he carried on manfully with the majority of his commitments.

During the last months of his life, in addition to all his other activities, he continued his researches in anæsthesia, and co-operated in the production of a CO_2 indicator.

He leaves a widow, a son and two daughters, to whom we extend our deepest sympathies.

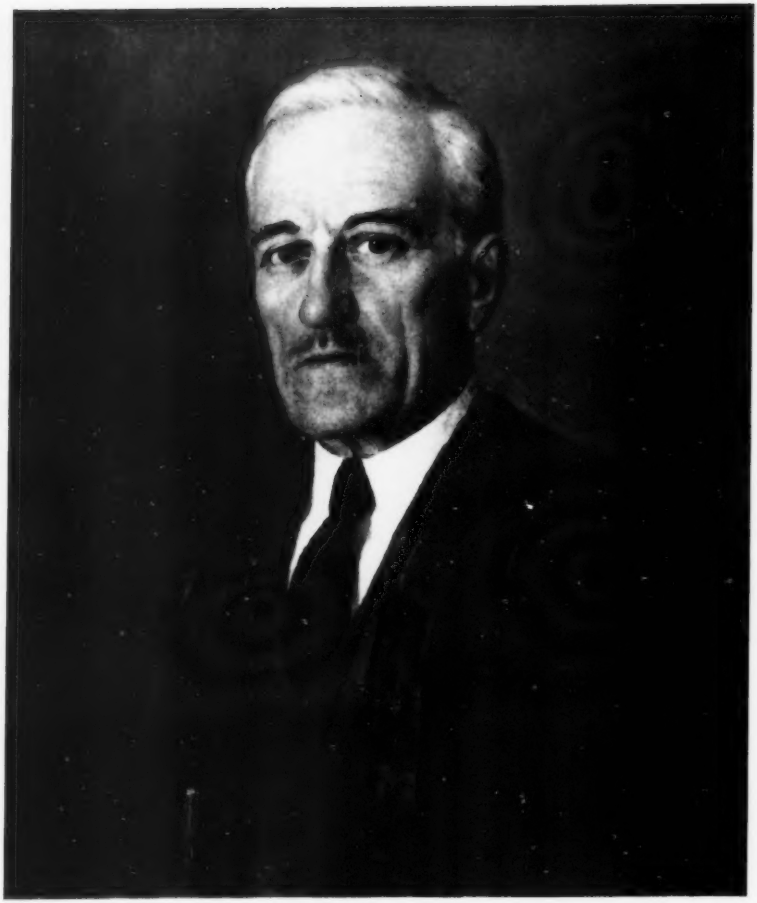
JOHN M. CLARK

It was with regret that we heard of the death of Dr. John M. Clark of Dundee. Dr. Clark was one of the senior anæsthetists North of the Border and for twenty-odd years was a reader of this Journal. Dr. Arthur Mills has written as follows:

By the death of Dr. John M. Clark, Dundee has lost one of its oldest anæsthetists. He was a graduate of St. Andrews University and was one of my earliest pupils in anæsthetics.

He was appointed Anæsthetist to the Dundee Royal Infirmary in 1921 and was attached there to Mr. John Anderson's surgical unit. He soon became an indispensable member of this team and the combination lasted for some fifteen years, until indeed Professor John Anderson's tragic death brought it to an end in 1935. They had been not only close colleagues in hospital and private work, but were bound in a close friendship. Clark felt the loss very badly and a period of indifferent health followed which persisted more or less and led to his retirement from the Infirmary in 1945.

Dr. Clark was an artist at his work and had an obvious pleasure in it. Brought up on the old ' rag and bottle ' he was critical of new types of apparatus and methods, but quick to adopt that which he considered sound and good. He was of a kindly nature and found great pleasure in his garden with its birds and flowers. As a colleague his kindness and his charity were ever evident.



WESLEY BOURNE

M.D., C.M., M.Sc., F.R.C.P.(C), F.I.C.A., F.A.C.A., F.F.A.R.C.S.

First Professor of Anæsthesia,
McGill University, Montreal

(From a painting by A. Sherriff Scott, R.C.A.)